6.6.4.6 Integrator Units

As shown in Figure 6.2 and Table 6.273, there are three identifiable watersheds in Quadrant III (labeled "A", "B", and "C"). Based on the information provided by the ODNR, and consistent with the SWMU by SWMU discussion of drainage in Section 6.6.2.2, the following assignment of SWMUs to each watershed (integrator unit) was made:

Watershed or Integrator Unit "A" includes:

- SWMU DMRQ

Watershed or Integrator Unit "B" includes:

- SWMUs X-230J3, X-230J5, X-326, X-330, X-530A, X-615, X-740, X-744S, X-745C, X-2230N, X-6619, BFS, and WDD
- SWMU X-744N soil samples HA1, HA4, and HA5

Watershed or Integrator Unit "C" includes:

- SWMU X-744N soil samples HA2, HA3, and HA6

The majority of the SWMUs are located in Unit "B". The following breakdown of sample stations by watershed can be made:

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Soil = 129 total stations

- Integrator Unit "A" = 20 (20 Phase I and 0 Phase II)
- Integrator Unit "B" = 144 (98 Phase I and 46 Phase II)
- Integrator Unit "C" = 3 (3 Phase I and 0 Phase II)

Sediment = 32 total stations

- Integrator Unit "A" = 9 (7 Phase I and 2 Phase II)
- Integrator Unit "B" = 27 (27 Phase I and 0 Phase II)
- Integrator Unit "C" = 0

Surface water = 6 total stations

- Integrator Unit "A" = 7 (7 Phase I and 0 Phase II)
- Integrator Unit "B" = 15 (6 Phase I and 9 Phase II)
- Integrator Unit "C" = 0

### 6.6.5 Environmental Fate of COCs

The partitioning of chemicals into particular environmental compartments and their ultimate fate can be predicted from key physico-chemical factors. The available physico-chemical factors for the COCs under evaluation in the Quadrant III PERA are presented in Appendix H.10. The information was obtained from a variety of secondary sources. The principal reference materials used were: (1) the Hazardous Substances Data Bank, a National Library of Medicine sponsored data bank that contains information on the fate and toxicology of over 4,300 potentially hazardous chemicals; (2) the four-volume

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Handbook of Environmental Fate and Exposure Data by P.H. Howard (1989, 1990, 1991, and 1993); (3) Montgomery and Welkom (1990); and (4) CHEMFATE, a Syracuse Research Corporation data bank. The factors that are most relevant for this assessment include volatility, water solubility, sorption to solids, octanol-water partitioning, and degradability.

Volatility describes how readily a compound will evaporate into the air from water, soil or sediment. Volatilization from water is expressed by the Henry's Law Constant, an air/water partition coefficient calculated by dividing the vapor pressure in atmospheres by water solubility in mole/$m^3$. Compounds with constants greater than $10^{-3}$ can be expected to volatilize readily from water, while those between $10^{-3}$ and $10^{-5}$ volatilize less readily. Compounds with constants less than $10^{-5}$ volatilize slowly. Volatility from soil or sediment tends to be expressed qualitatively (e.g., moderate, readily, or rapid).

Water solubility (mg/L) of a compound influences its partitioning to aqueous media. Highly water soluble chemicals have a tendency to remain dissolved in the water column and not partition to soil or sediment. Compounds with high water solubilities generally exhibit lower tendencies to bioconcentrate in aquatic organisms, a lower degree of volatility, and a greater likelihood of biodegradation.

Adsorption is a measure of a compound's affinity for solids in soil or sediment. Adsorption is expressed in terms of partitioning, either $K_d$ (adsorption coefficient; unitless expression of the equilibrium concentration in the solid phase versus in the water phase) or as $K_{oc}$ ($K_d$ normalized to the organic carbon content of the solid phase; again unitless). The higher the $K_{oc}$ or $K_d$ values, the higher the tendency to adhere very strongly to soil or sediment particles. $K_{oc}$ values were used in calculating non-ionic organic sediment benchmarks for the PERA.

The octanol/water partition coefficient or $K_{ow}$ is a measure of the relative partitioning between octanol and water and demonstrates whether a compound is hydrophilic or hydrophobic. It has also been shown to correlate well with bioconcentration factors in aquatic organisms and adsorption to soil or sediment particles and the potential to bioaccumulate in the food chain. Typically expressed as log $K_{ow}$, a value of 3 or less generally indicates that the chemical may not bioconcentrate to a significant degree (Maki and Duthie 1978). A log $K_{ow}$ of 3 equates to an aquatic species bioconcentration factor of about 100, using the correlation log BCF = 0.76 log $K_{ow}$ - 0.23 (from Lyman et al. (1990). Table 6.312 presents all compounds detected in any media with a log $K_{ow}$ greater than 3. These compounds could then be used in foodchain modeling to determine risks to organisms.

Degradability is an important factor in determining whether there will be significant loss of mass of a substance over time in the environment. The half-life ($T_{1/2}$) of a compound can be used to describe losses from either degradation (i.e., biological or abiotic) or from transfer from one compartment to another (e.g., volatilization from soil to air). The half-life is the time required for one-half of the mass of a compound to undergo the loss or degradation process.

### 6.6.6 Derivation of Screening Benchmarks

In the PERA, the estimated RME exposure concentration for a given COC in a given medium (i.e., represented by the 95% UCL on the mean or the maximum measured level, whichever is less, for the quadrant-wide analysis, and the maximum measured level for the analysis of individual SWMUs) is compared to one or more adverse effect threshold values or benchmarks. The objective of this comparison is to screen the COCs to determine, qualitatively, which are likely (and, alternatively, which are unlikely) to pose

a risk to ecological receptors at the site. Where available, the effect threshold value is a media-specific screening benchmark set forth by federal or state agencies. There are no established screening benchmarks, however, for a number of the PORTS COCs in one or more of the environmental media assessed. In these cases, the PERA methodology calls for deriving screening benchmarks based on available data and best professional judgement. The general methods of deriving screening benchmarks proposed in the Quadrant IV RFI Work Plan (Geraghty & Miller, Inc., 1992g) were used in this PERA. Some modifications were made to the PERA methodology based on instructions from ORNL personnel during the PERA process.

#### 6.6.6.1 Surface Water Screening Benchmarks

The following procedure was used in the PERA. The calculated RME surface water concentrations were compared to all benchmark values available for each COC. If the RME surface water concentration exceeded any of these benchmarks, that COC was flagged for further analysis in a more detailed assessment, such as a BERA. If none of the benchmarks were exceeded, the COC was eliminated from further consideration.

Surface Water Screening Benchmarks from Suter et al. (1992)

Table 1 from Suter et al. (1992) contains up to eight surface water benchmark values for various inorganic and organic chemicals. This table has been reproduced as Table 6.303 for the applicable Quadrant III COCs. According to Suter et al. (1992), each benchmark was derived to protect aquatic organisms. The eight benchmarks include: (1) acute national ambient water quality criteria (NAWQC) or advisory values; (2) chronic

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NAWQC or advisory values;[10] (3) lowest chronic toxicity value reported for fish; (4) lowest chronic toxicity value reported for daphnids; (5) lowest test $EC_{20}$ value (effect concentration correlated with a 20 percent response) reported for fish; (6) lowest test $EC_{20}$ value reported for daphnids; (7) most sensitive aquatic species $EC_{20}$; and (8) largemouth bass population EC20. The following screening procedure was used in the PERA. The calculated RME surface-water concentrations were compared to all benchmark values available for each COC as presented in Table 6.303. If the RME surface water concentration exceeded any one benchmark, that COC was considered to be a potential hazard. If none of the benchmarks were exceeded, the COC was not considered a potential hazard. Where information was available for different valence states of a COC (i.e., arsenic III versus arsenic V), the more toxic of the two was used during the screening process.

All inorganic COCs detected in Quadrant III surface water (except calcium) had one or more benchmarks available in Suter et al. (1992). Benchmarks were also available for eight of the nineteen organic COCs detected in surface water (anthracene, benzo[a]anthracene, gamma-BHC, chloroform, ethylbenzene, fluoranthene, phenanthrene, and xylene).

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[10]Chronic advisory values included in the Suter et al. (1992) summary of benchmark values were not included as benchmarks in the PERA per instructions from ORNL (R. Hull, personal communication, 1994a), and do not appear in Table 6.303. Advisory values were substantially lower than other water quality guidelines and standards presented in Suter et al. (1992) and were judged to be too conservative to serve as a useful screening tool. The original screening methodology of Suter et al., which included comparison to chronic advisory values, required that the constituent concentration in surface water exceed two benchmarks in order for the chemical to be considered a potential hazard. Refinement of the methodology by eliminating advisory values and requiring an exceedence of only one benchmark value did not materially influence the outcome of the PERA surface water analysis.

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Surface Water Screening Benchmarks Derived Using the Methodology Described in the Quadrant IV Work Plan

When benchmarks were not available in Suter et al. (1992), they were derived using the method described in the Quadrant IV Work Plan. An upper and lower benchmark were derived for ten other organic COCs detected in surface water (bromodichloromethane, 2-chlorophenol, dibromochloromethane, 1,2-dibromo-3-chloropropane, 1,4-dioxane, isobutyl alcohol, isophorone, kepone, pentachlorophenol, and pyrene). No aquatic toxicity data were available for calcium or O,O,O-triethylphosphorothioate, and therefore a benchmark could not be derived for these COCs. Where NAWQC values were available from sources other than Suter et al. (1992), the acute NAWQC value was used as the upper benchmark and the chronic NAWQC value was used as the lower benchmark. Where a chronic NAWQC was unavailable, a NAWQC Lowest Observable Effect Level (LOEL) was used in its place. Where no chronic NAWQC LOEL was available, the lowest $LC_{50}$ (concentration found to be lethal to 50 percent of a population of test organisms) reported in AQUIRE was used as an upper benchmark. This value was divided by 100 to arrive at a lower benchmark. Table 6.304 presents the upper and lower benchmarks for COCs not in Table 6.303. Thus, the surface water concentrations (i.e., quadrant-wide RME and SWMU-specific maxima) for these ten organic COCs were compared to the upper and lower derived benchmarks in the PERA. Any COC that exceeded an upper or lower benchmark was flagged for further analysis in a more rigorous assessment such as a BERA.

6.6.6.2 Sediment Screening Benchmarks

Sediment screening benchmarks are presented in Tables 6.305 to 6.308. Screening benchmarks from Hull and Suter (1994) were used where available. Sediment benchmarks were available for inorganic COCs and ionic organic COCs (Hull and Suter, 1993).

Sediment benchmarks for non-ionic organic COCs were derived from aquatic benchmarks using the equilibrium partitioning approach (USEPA, 1993c).

Sediment Screening Benchmarks for Inorganic COCs

For each inorganic COC, there were upper and lower sediment benchmark values available (Hull and Suter, 1994). If available, the National Oceanic and Atmospheric Administration (NOAA) Apparent Effects Threshold (AET) and the NOAA Effects Range-Low (ER-L) were used as the upper and lower benchmarks, respectively. Where the AET was unavailable for a particular COC, the NOAA Effects Range-Median (ER-M) was used as the upper benchmark, if available. Where AET and ER-L or ER-M values were unavailable, instructions on inorganic sediment benchmarks were provided on a case-by-case basis by ORNL (Hull, personal communication, 1994b). The sources of all inorganic benchmark values are included in Table 6.305. If either the upper or lower benchmark was exceeded by the RME sediment concentration, the inorganic COC was retained for analysis in a more detailed future assessment, such as a BERA. Sediment benchmarks were unavailable for 10 inorganic COCs (aluminum, beryllium, calcium, cobalt, fluoride, magnesium, potassium, sodium, thallium, and vanadium); these COCs could not be evaluated.

Non-ionic Organic Sediment Screening Benchmarks Calculated Using U.S. EPA Values

Sediment screening benchmarks (Table 6.306a) were available from U.S. EPA for four non-ionic COCs (acenaphthene, dieldrin, fluoranthene, and phenanthrene) (U.S. EPA, 1993a-e, as cited in Hull and Suter, 1994). These values were available in units of $\mu$g/g organic carbon and were converted to $\mu$g/kg sediment assuming 4% organic carbon in

sediment in the absence of measured values (Mackay et al., 1992). This assumption of an organic carbon value for sediment is a source of uncertainty in the PERA.

Non-ionic Organic Sediment Screening Benchmarks Derived Using Aquatic Benchmarks from Suter et al. (1992)

For non-ionic (neutral) organic COCs, Hull and Suter (1994) suggest that sediment benchmarks be derived using the equilibrium partitioning approach (as described in U.S. EPA, 1993c) and aquatic (surface water) screening benchmarks. These screening benchmarks were compared to RME concentrations using the same procedure as described for surface water. An exceedence of any of these benchmarks suggests a potential risk, and the COC was flagged for further evaluation in a more detailed assessment, such as a BERA. Sediment screening benchmarks for non-ionic organic COCs were derived by muliplying the surface water scrrening benchmark by the $K_{oc}$ and the $F_{oc}$ (fraction organic carbon content of the sediment). The sediment $F_{oc}$ in Quadrant III was assumed to be 4% in the absence of measured values (Mackay et al., 1992). Benchmarks (Table 6.306b) were available using this methodology for 11 non-ionic organic COCs (anthracene, Aroclor-1260, benzo[a]anthracene, benzo(a)pyrene, carbon disulfide, chloroform, dibenzofuran, naphthalene, tetrachloroethene, trichloroethene, and xylene).

Non-ionic Organic Sediment Screening Benchmarks Derived Using Surface Water Benchmarks

There were nine non-ionic organic COCs for which aquatic surface water benchmarks were not available in Suter et al. (1992). In the absence of aquatic surface water screening benchmarks, which are used to derive sediment benchmarks, the methodology described in the Quadrant IV Work Plan (Geraghty & Miller, Inc. 1992g) was

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used to derive both upper and lower aquatic screening benchmarks. The aquatic benchmarks were converted to sediment benchmarks using the equilibrium partitioning approach, as described above. These organic sediment benchmarks are presented in Table 6.307.

The upper aquatic surface water benchmark used to derive sediment benchmarks was equivalent to the acute NAWQC. Where a NAWQC was unavailable, an acute NAWQC Lowest Observable Effect Level (LOEL) was used in its place. If an acute NAWQC LOEL value was unavailable, the lowest acute $LC_{50}$ available in the literature was used as the upper screening benchmark. Where an $LC_{50}$ was unavailable, an $EC_{50}$ (the concentration of a chemical found to cause a particular effect in 50 percent of a population of aquatic organisms) was used.

The lower aquatic surface-water benchmark used to derive sediment benchmarks was a chronic NAWQC, where available. When a chronic NAWQC was not available, the lowest chronic toxicity value was divided by a factor of 10 to estimate a lower screening benchmark. Where no chronic toxicity data were available, the lower screening benchmark was derived by dividing the lowest acute $LC_{50}$ available in the literature by a factor of 100. These are conservative factors in that most measured chronic values would typically be higher than those estimated from these factors (Suter et al., 1983, as cited in the Quadrant IV Work Plan).

If either the upper or lower benchmark was exceeded by the RME concentration, the COC was retained for possible future analysis in the BERA.

For ionic organic COCs, Hull and Suter (1994) suggest the use of Washington State sediment quality standards (provided in Table 6 of Hull and Suter, 1994). That table is

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reproduced here as Table 6.308 for the two ionic organic COCs detected in Quadrant III sediment. A benchmark was available for 4-methylphenol but not 2-chlorophenol.

6.6.6.3 Plant Toxicity Screening Benchmarks in Soil

For terrestrial plants, the benchmark levels are selected such that a level of a COC below the benchmark allows for vegetative cover "that is sufficiently complete and robust to prevent erosion" (Quadrant IV Work Plan; Geraghty & Miller, Inc., 1992g). Under current use, this endpoint is not relevant for most of the eastern portion (inside Perimeter Road) of Quadrant III because of the industrial nature (lack of vegetation due to pavement) of this area. However, as shown in Figure 6.2, a substantial portion of Quadrant III is comprised of forested and grassy areas and therefore appear to have ample existing vegetation. This suggests that contaminant levels in much of Quadrant III are low enough that vegetation is able to exist. The extent to which plant species present may be pollution tolerant, however, is not known.

No relevant federal or state benchmarks were found relating soil chemical concentrations to plant toxicity. Therefore, benchmarks were derived based on the lowest concentration reported to be toxic to plants. The plant benchmarks for inorganic COCs were taken from Table 1 of Suter et al. (1993) and are reproduced here as Table 6.309. Phytotoxicity information was unavailable for five inorganic COCs (calcium, cyanide, magnesium, potassium, and sodium). Phytotoxicity information for organic COCs was obtained from the U.S. EPA's PHYTOTOX data base and is presented in Table 6.310. There were 29 organic COCs for which no plant toxicity data were available, and therefore benchmarks could not be derived. COCs with no toxicity data could not be evaluated.

Some of the toxicity data were based on nutrient solution rather than bulk soil exposure experiments. These data are flagged in Tables 6.309 and 6.310. Since concentration in nutrient solution was assumed to be equivalent to a concentration in soil, they would represent a conservative estimate of bioavailability and toxicity in the soil. This is a source of uncertainty in the PERA. In addition, a number of the phytotoxicity data were reported in concentrations expressed as molar quantities. These values were converted to $\mu$g/L as per the following example:

> A plant toxicity study using benzo(a)anthracene was identified in PHYTOTOX (Kochhar and Sabharwal, 1977). The experiment was conducted with *Nicotiana tabacum* in a nutrient medium. Morphogenetic effects were studied in plants at molar concentrations ranging from $10^{-11}$ to $10^{-5}$. The lowest concentration of benzo(a)anthracene where effects were observed was $10^{-9}$ M. The equivalent concentration in soil was calculated by converting from grams/mol into $\mu$g/L (ppb):
>
> $(1 \times 10^{-9}$ mols/liter)(228 g/mol)$(10^{6}$ $\mu$g/g) = 0.227 $\mu$g/liter = 0.227 ppb

Soil benchmarks for inorganic COCs, in many cases, were well below the tentative background levels derived for the PORTS facility (see table below). This adds a considerable degree of uncertainty to the assessment of potential risks to plants for these COCs.

**Inorganic COCs With Plant Benchmarks Below Tentative Background Levels at PORTS**

| COC | Benchmark (mg/kg) | Background (mg/kg) |
|---|---|---|
| Aluminum | 50 | 29,268 |
| Arsenic | 10 | 23 |
| Chromium | 2 | 26 |

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| Inorganic COCs With Plant Benchmarks Below Tentative Background Levels at PORTS | | |
|---|---|---|
| **COC** | **Benchmark (mg/kg)** | **Background (mg/kg)** |
| Iron | 10 | 47,768 |
| Nickel | 1 | 51 |
| Vanadium | 2.5 | 63 |
| Zinc | 25 | 90 |

### 6.6.6.4 Soil Invertebrate Screening Benchmarks

Screening benchmarks for soil invertebrates are presented in Table 6.311. Benchmarks for some COCs were provided by ORNL (Will, personal communications, 1994a,b). For other COCs, benchmarks were derived if appropriate toxicity studies were available in the scientific literature. As per instructions from ORNL (Will, personal communication, April 1994b), screening benchmarks for soil invertebrates were derived using the methodology for inorganic plant screening benchmarks outlined in Suter et al. (1993). This method is based on the NOAA method for deriving the ER-L for sediment screening benchmarks (Long and Morgan, 1990). The soil invertebrate screening benchmarks were derived by rank ordering all available lowest observed effect concentration (LOEC) values and then selecting the value that approximated the 10th percentile of the data. In every case less than ten studies were available for each COC, and the lowest toxicity value was chosen. In cases where LOEC data were not available, $LC_{50}$ values divided by a factor of ten were substituted (Will, personal communication, 1994b).

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6.6.6.5 Radionuclide Screening Benchmarks

Environmental media screening benchmarks for radionuclides are unavailable. Ecological risks from radionuclides were assessed on a quadrant-wide basis in the Phase I RFI, Quadrant I Ecological Risk Assessment (Geraghty & Miller, 1992b; Appendices L.4, L.5, and L.9). As an alternative to reproducing the detailed assessment done previously, the RME levels of radionuclides calculated for the Quadrant III PERA have been compared with the RME levels calculated in the Quadrant I and II Phase I RFIs in order to screen for potential adverse impacts (see table below).

For the Phase I RFI, the radionuclide environmental monitoring data were converted to radiologic dose levels ($\mu$Gy/hr) received by selected indicator species -- aquatic organisms (i.e., minnows, largemouth bass and suckers), semi-aquatic organisms (i.e., mink), and terrestrial organisms (i.e., great blue heron and white-tailed deer) -- using the CRITR method (NCRP, 1991). Technetium and uranium data were combined to obtain a measure of total radionuclide exposure. Exposures were estimated by combining data from the various environmental media sampled. In addition, the monitoring data from Quadrants I and II (uranium and technetium levels in soil, sediment, or surface water; from either Quadrant I or II) were combined into a single data set to determine radiologic dose levels which were then used in both the Quadrant I and Quadrant II Phase I RFI ecological risk assessments. These dose levels were compared to proposed "benchmarks" of 400 $\mu$Gy/hr for aquatic organisms (NCRP, 1991) or a no adverse effect level on populations of 40 $\mu$Gy/hr for terrestrial organisms (IAEA, 1991).

The table below presents the 1992 Quadrant I and II (Phase I) and Quadrant III 1994 (Phase I and Phase II) RME concentrations, by environmental medium, for technetium and

uranium. The potential for ecological damage from radionuclide exposure is evaluated in Section 6.6.7.1.3.

**Comparison of 1992 Quadrant I/II and 1994 Quadrant III RMEs for Radionuclides**

| Environmental Medium | Technetium (pCi/kg) | | Uranium (μg/g) | |
|---|---|---|---|---|
| | Quadrant I/II[1] (Phase I) | Quadrant III (Phase I/II) | Quadrant I/II[1] (Phase I) | Quadrant III (Phase I/II) |
| Sediment | 4,100 | 1,525 | 7.0 | 7.1 |
| Surface Water[2] | 5.4 | -- | 45 | -- |
| Soil | 100,000 | 568 | 180 | 3.6[3] |

1 Represents RME concentration in either Quadrant I or Quadrant II (Phase I) samples.
2 In pCi/L for technetium and μg/L for uranium.
3 As shown in Table 6.277 the RME concentration for uranium in Quadrant III soil was below background and was therefore dropped from further assessment in the PERA.

### 6.6.6.6 Screening Benchmarks for Bioaccumulation Potential

In addition to direct exposure to a COC in water, sediment, and/or soil, there is also the potential for exposure to an ecological receptor as a consequence of bioaccumulation through the foodchain. Examples include:

- water/sediment ▸ fish ▸ piscivorous wildlife;
- soil ▸ plant ▸ herbivore; and
- soil ▸ soil invertebrate ▸ insectivore ▸ carnivore.

The bioaccumulation of lipophilic organic compounds can be screened using the octanol-water partitioning coefficient ($K_{ow}$); a log $K_{ow}$ of three (3.0) or greater is considered

a reasonable screen for bioaccumulation potential (Maki and Duthie, 1978). Table 6.312 lists the organic COCs detected in Quadrant III that have log $K_{ow}$ values greater than three. Where more than one $K_{ow}$ value was available, the midpoint of the range of values was used.

Screening benchmarks are not available for bioaccumulation of metals or for bio-uptake of any COCs into higher plants. However, some heavy metals are known to be taken up by plants, and organic forms of certain metals bioaccumulate in the foodchain (e.g., organo-mercury and organo-lead). Although screening benchmark, such as the $K_{ow}$ used for lipophilic organics, is not available for plants, $B_v$ values could be used to calculate plant uptake and exposure in a more detailed assessment, such as a BERA (Baes et al., 1984).

In summary, with the exception of log $K_{ow}$ values for organic compounds, screening level bioaccumulation benchmarks were not identified for the COCs in Quadrant III. The compounds with a $K_{ow}$ greater than three (Table 6.312) can be evaluated for foodchain exposure to organisms in a more detailed assessment, such as a BERA.

The following SWMUs contain organic COCs with log $K_{ow}$ values greater than three: X-230J3 (PAHs, dibenzofuran, tetrachloroethene, and xylene in soil); X-230J5 (PAHs, Aroclor-1260, dibenzofuran, and 1,2,4-trichlorobenzene in sediment); X-530A (PAHs, Aroclor-1260, dibenzofuran, chlorobenzenes, ethylbenzene, and tetrachloroethene in soil); X-615 (PAHs, Aroclor-1260, dibenzofuran, and tetrachloroethene in soil); X-740 (PAHs in soil); X-744N (PAHs, pesticides, ethylbenzene, tetrachloroethene, 1,2,4-trichlorobenzene, and xylene in soil); X-744S (PAHs, Aroclor-1260, ethylbenzene, tetrachloroethene, and xylene in soil); X-745C (PAHs, PCBs, dibenzofuran, tetrachloroethene, and xylene in soil); X-2230N (PAHs, Aroclor-1260, dibenzofuran, and xylene in sediment and Aroclor-1248 in soil); BFS (PAHs, pesticides, and tetrachloroethene

in soil); DMRQ (PAHs, 2,4-dichlorophenol, tetrachloroethene, and xylene in soil and PAHs in surface water); WDD (PAHs, Aroclor-1260, dieldrin, dibenzofuran, tetrachloroethene, and xylene in sediment, and PAHs, pesticides, ethylbenzene, pentachlorophenol, and xylene in surface water).

### 6.6.7 Comparison of Constituents of Concern with Screening Benchmarks

The purpose of comparing the RME concentrations of COCs to available or derived toxicity benchmarks is to screen the COCs for potential ecological risks and to identify those COCs which require further analysis in a more detailed ecological risk assessment, such as a BERA. The PERA approach involved a determination of whether or not screening benchmarks were exceeded. In cases where the PERA analysis results in an exceedence, regardless of the magnitude, the COC (and associated environmental medium and SWMU) is flagged for further consideration. In cases where the screening benchmarks were not exceeded, the COC (and environmental medium and SWMU) was eliminated from further consideration. The elimination of COCs by this method can be made with confidence because of the generally conservative assumptions used in deriving the screening benchmarks. In the Quadrant III PERA, there are some COCs for which screening benchmarks could not be developed for a particular medium because of lack of appropriate toxicity data; these COCs are noted in Table 6.313.

#### 6.6.7.1 Quadrant-Wide Comparisons

Tables 6.314 to 6.316 summarize the quadrant-wide COC data by environmental medium. Table 6.317 summarizes the results of comparing the quadrant-wide RME concentration for each COC, by environmental medium, to the benchmarks derived using the methods described in previous sections.

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6.6.7.1.1 Inorganic COCs

Twenty-three inorganic COCs were detected in sediment, 22 in surface water, and 25 in soil. Over half (17 out of 25) of inorganic COCs detected in soil, however, had RME levels below background; accordingly, these 17 COCs were not considered in the quadrant-wide comparison. Benchmarks were available, or derived, for many of the inorganic COCs that were taken through the quadrant-wide comparison: sediment (13/23), surface water (21/22), plant toxicity in soil (3/8), and invertebrate toxicity in soil (0/8).

There were 7 exceedences in sediment (antimony, arsenic, barium, cyanide, iron, manganese, and zinc); 17 in surface water (aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, sodium, vanadium, and zinc); and 1 exceedence in soil (lithium). As a result of the quadrant-wide comparison, all detected inorganic chemicals either exceeded at least one benchmark in an environmental medium, or did not have a benchmark in at least one environmental medium, and all were identified for further analysis in a more detailed assessment, such as a BERA.

6.6.7.1.2 Organic COCs

Twenty-seven of the 60 organic COCs were detected in sediment, 19 in surface water, and 49 in soil. Benchmarks were available or derived for the organic COCs as follows: sediment (24/27), surface water (18/19), plant toxicity in soil (17/49), and invertebrate toxicity in soil (6/49).

There were 11 exceedences in sediment (acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene,

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dibenz[a,h]anthracene, fluoranthene, phenanthrene, and pyrene); 3 in surface water (anthracene, benzo[a]anthracene, and pyrene); 6 in soil for exceedences of plant toxicity benchmarks (benzo[a]anthracene, benzo[a]pyrene, 2-chlorophenol, 4,4'-DDT, dibenz[a,h]anthracene, 2,4-dichlorophenol); and 2 in soil for exceedences of soil invertebrate toxicity benchmarks (phenol and 1,2,4-trichlorobenzene). Based on the quadrant-wide analysis, nine organic COCs were dropped from further consideration (gamma-BHC, carbon disulfide, dibromochloromethane, 1,2-dibromo-3-chloropropane, 1,4-dioxane, isobutyl alcohol, isophorone, kepone, and pentachlorophenol).

6.6.7.1.3 Radionuclides

As stated in Section 6.6.6.5, a screening-level analysis of potential ecological risks associated with radionuclides has been performed. This analysis consisted of comparing the quadrant-wide RME concentrations of uranium and technetium in Quadrant III media to the RME concentrations in the Quadrant I/Quadrant II Phase I RFI. A detailed assessment of potential ecological risk for radionuclides was performed as part of the Phase I RFIs for Quadrants I and II.

The analysis of potential ecological risk from exposure to radionuclides presented in the 1992 Quadrant I/Quadrant II Phase I RFIs showed negligible risks to fish and wildlife with the exception of the great blue heron, for which the calculated dose in $\mu$Gy/hr exceeded the screening benchmark by a marginal factor of 1.1. In interpreting the results of the analysis for the heron, consideration was given to the conservative assumptions incorporated in estimating radionuclide dose to the heron, including the following: the use of the detection limit for radionuclides in fish tissue (a major component of the heron diet) where tissue levels were reported as non-detects; the assumption of no excretion of radionuclides from the heron; and the assumption of year-round residency for the great blue

heron, a migratory species. Given the nature of these assumptions and the small factor by which the benchmark for the heron was exceeded, it is unlikely that radionuclide levels in Quadrant I/Quadrant II media present a significant risk to ecological receptors.

The table in Section 6.6.6.5 compares average Quadrant III radionuclide concentrations (based on Phase I and II sampling data collected through 1994) to average Quadrant I and II radionuclide concentrations (based on 1992 Phase I sampling data). Radionuclides were not detected in the 1994 Quadrant III surface water samples and therefore can be eliminated from further consideration for potential ecological risk in Quadrant III. Radionuclide levels in 1994 Quadrant III soil samples were substantially lower than in 1992 Quadrant I/II soil samples and should therefore pose negligible risks. Technetium levels were substantially lower in Quadrant III sediment samples than in Quadrant I/II sediment samples (1,525 vs. 4,100 pCi/kg) while uranium levels were comparable (7.1 vs. 7.0 $\mu$g/g). In summary, the RME concentrations for radionuclides in Quadrant III were comparable to or lower than the RME concentrations calculated in the Quadrant I/II Phase I assessment. Because the Quadrant I/II Phase I assessment suggested that radionuclides should not present a significant risk to ecological receptors, radionuclide levels in Quadrant III media should not present a significant ecological risk. Additional consideration of the potential ecological risks posed by radionuclides appears in the BERA for the Upper Little Beaver Creek and Big Run Creek Watersheds (ORNL, 1994b).

### 6.6.7.2 SWMU by SWMU Comparison

The following subsections summarize, first by environmental medium and then by SWMU, the number of chemicals detected and the number of chemicals in which RME levels exceeded benchmarks. The relevant data are summarized in Appendices H.11 and H.12 for inorganics and organics, respectively.

6.6.7.2.1 Analysis by Environmental Medium

Sediment

Sediments were sampled at four SWMUs: WDD, X-230J5, X-2230N, and DMRQ. SWMU WDD has the greatest number of inorganic COCs detected in sediment (23) and, along with X-230J5, had the most inorganic COCs for which there were benchmarks (12). WDD also had the greatest number and percentage of inorganic COCs above a benchmark (11 or 92% of COCs with a benchmark). SWMUs X-230J5, X-2230N, and DMRQ had eight, seven, and five exceedences of sediment inorganic benchmarks, respectively. Five inorganic COCs (arsenic, barium, iron, manganese, and zinc) exceeded benchmarks in all four SWMUs.

| Inorganics - Sediment | | | |
|---|---|---|---|
| **SWMU** | **Number of COCs Detected** | **Number with Benchmarks** | **Number Exceeding Benchmarks (% Evaluated)** |
| WDD | 23 | 12 | 11 (92%) |
| X-230J5 | 21 | 12 | 8 (67%) |
| X-2230N | 21 | 10 | 7 (70%) |
| DMRQ | 20 | 10 | 5 (50%) |

SWMU WDD had the most organic COCs detected (24) in sediment and the most organic COCs with benchmarks (21). SWMU WDD also had the greatest number and percentage of organic COCs that exceeded benchmarks (14 exceedences, 67%). No organic COCs exceeded benchmarks in sediments at DMRQ. Three PAH compounds

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(anthracene, benzo[g,h,i]perylene, and chrysene) exceeded sediment benchmarks in two of the other three SWMUs.

| Organics - Sediment | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| WDD | 24 | 21 | 14 (67%) |
| X-230J5 | 20 | 17 | 10 (59%) |
| X-2230N | 17 | 15 | 4 (27%) |
| DMRQ | 2 | 2 | 0 (0%) |

Surface Water

Surface-water samples were taken from three SWMUs (WDD, X-2230N, and DMRQ). SWMU DMRQ had the most inorganic COCs detected (22) in surface water and the most detected for which benchmarks were available (21); all detected inorganic COCs except calcium had available benchmarks. For inorganic COCs in surface water, SWMU DMRQ also had the greatest number (17) and percentage (81%) of COCs exceeding benchmarks. Zinc was the only inorganic COC that exceeded surface water benchmarks in all three SWMUs.

| Inorganics - Surface Water | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| WDD | 11 | 10 | 7 (70%) |

| Inorganics - Surface Water | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| X-2230N | 2 | 2 | 1 (50%) |
| DMRQ | 22 | 21 | 17 (81%) |

SWMU WDD had the most organic COCs detected in surface water (15) and the most organic COCs with benchmarks (14); all detected organic COCs except O,O,O-triethylphosphorothioate had available benchmarks. For organic COCs in surface water, DMRQ had the greatest number (2) and percentage (33%) of COCs exceeding benchmarks. No organic COCs were detected at SWMU X-2230N.

| Organics - Surface Water | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| WDD | 15 | 14 | 1 (7%) |
| X-2230N | 0 | -- | 0 (0%) |
| DMRQ | 6 | 6 | 2 (33%) |

Soil

Soil samples were analyzed for inorganic and organic COCs at 15 SWMUs (X-230J3, X-230J5, X-326, X-330, X-530A, X-615, X-740, X-744N, X-744S, X-745C, X-2230N, X-6619, BFS, DMRQ and WDD). Maximum concentrations of inorganic chemicals in soils were compared to background soil concentrations, where available (Tables 6.279 to 6.300). A number of inorganic COCs were dropped from consideration

at several SWMUs because the maximum levels were below background. Inorganic COCs detected at levels above background and all detected organic COCs were compared to available soil benchmarks, which were based on phytotoxicity and toxicity to soil invertebrates.

Toxicity to Plants: SWMU X-745C had the greatest number of inorganic COCs detected in soil at levels above background (18), the greatest number of phytotoxicity benchmarks available (13), and the greatest number of exceedences (7). X-744N had the greatest percentage of exceedences of inorganic phytotoxicity benchmarks (100%). No inorganic COC exceeded its plant toxicity benchmark in every SWMU; zinc exceeded its soil phytotoxicity benchmark most frequently (9 of 15 SWMUs). No inorganic COCs were detected at levels above background in four SWMUs (X-230J5, X-326, X-330, and WDD).

| Inorganics - Phytotoxicity in Soil | | | |
|---|---|---|---|
| **SWMU** | **Number of COCs Detected Above Background** | **Number with Benchmarks** | **Number Exceeding Benchmarks (% Evaluated)** |
| X-230J3 | 6 | 3 | 2 (67%) |
| X-230J5 | 0 | -- | ---- |
| X-326 | 0 | -- | ---- |
| X-330 | 0 | -- | ---- |
| X-530A | 13 | 7 | 5 (71%) |
| X-615 | 12 | 7 | 4 (57%) |
| X-740 | 10 | 7 | 5 (71%) |
| X-744N | 5 | 2 | 2 (100%) |
| X-744S | 6 | 3 | 2 (67%) |
| X-745C | 18 | 13 | 7 (54%) |
| X-2230N | 2 | 2 | 1 (50%) |
| X-6619 | 6 | 3 | 1 (33%) |

| Inorganics - Phytotoxicity in Soil | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected Above Background | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| BFS | 11 | 7 | 5 (71%) |
| DMRQ | 11 | 7 | 6 (86%) |
| WDD | 0 | -- | ---- |

SWMU X-530A had the greatest number of organic COCs detected (31), the greatest number of organic COCs with phytotoxicity benchmarks (11), and the greatest number of organic COCs exceeding plant toxicity benchmarks (5). X-740 and X-744N had the greatest percentage of organic COCs exceeding plant toxicity benchmarks (67%). No organic COCs exceeded the plant toxicity benchmark at every SWMU; benzo(a)pyrene exceeded its soil phytotoxicity benchmark most frequently (7 of 15 SWMUs). No organic COCs were detected in two SWMUs (X-326 and X-330).

| Organics - Phytotoxicity in Soil | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| X-230J3 | 22 | 7 | 4 (57%) |
| X-230J5 | 2 | 0 | ---- |
| X-326 | 0 | -- | ---- |
| X-330 | 0 | -- | ---- |
| X-530A | 31 | 11 | 5 (45%) |
| X-615 | 19 | 6 | 2 (33%) |
| X-740 | 15 | 3 | 2 (67%) |
| X-744N | 16 | 3 | 2 (67%) |
| X-744S | 22 | 7 | 2 (29%) |

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| Organics - Phytotoxicity in Soil | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| X-745C | 29 | 10 | 3 (30%) |
| X-2230N | 2 | 0 | ---- |
| X-6619 | 1 | 0 | ---- |
| BFS | 11 | 2 | 0 (0%) |
| DMRQ | 19 | 8 | 2 (25%) |
| WDD | 1 | 0 | ---- |

Toxicity to Soil Invertebrates: SWMU X-745C had the greatest number of inorganic COCs detected in soil at levels above background (18) and the greatest number of soil invertebrate toxicity benchmarks available (8). Six SWMUs (X-230J3, X-530A, X-615, X-740, X-745C, and DMRQ) had the greatest number of exceedences (1). X-230J3 had the greatest percentage of exceedences of inorganic soil invertebrate toxicity benchmarks (50%). No inorganic COC exceeded its soil invertebrate toxicity benchmark at every SWMU; chromium exceeded its soil invertebrate toxicity benchmark most frequently (5 of 15 SWMUs). No inorganic chemicals were detected at levels above background at four SWMUs (X-230J5, X-326, X-330, and WDD).

| Inorganics - Invertebrate Toxicity in Soil | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected Above Background | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| X-230J3 | 6 | 2 | 1 (50%) |
| X-230J5 | 0 | -- | ---- |
| X-326 | 0 | -- | ---- |

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| Inorganics - Invertebrate Toxicity in Soil | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected Above Background | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| X-330 | 0 | -- | ---- |
| X-530A | 13 | 3 | 1 (33%) |
| X-615 | 12 | 4 | 1 (25%) |
| X-740 | 10 | 4 | 1 (25%) |
| X-744N | 5 | 1 | 0 (0%) |
| X-744S | 6 | 1 | 0 (0%) |
| X-745C | 18 | 8 | 1 (13%) |
| X-2230N | 2 | 2 | 0 (0%) |
| X-6619 | 6 | 2 | 0 (0%) |
| BFS | 11 | 5 | 0 (0%) |
| DMRQ | 11 | 3 | 1 (33%) |
| WDD | 0 | -- | ---- |

SWMU X-530A had the greatest number of organic COCs detected (31), the greatest number of organic COCs with soil invertebrate toxicity benchmarks (5), and the greatest number of organic COCs exceeding soil invertebrate toxicity benchmarks (2). X-744N and BFS had the greatest percentage of organic COCs exceeding soil invertebrate toxicity benchmarks (100%). No organic COC exceeded the soil invertebrate toxicity benchmark in every SWMU; phenol exceeded its soil invertebrate toxicity benchmark most frequently (4 of 15 SWMUs). No organic COCs were detected in two SWMUs (X-326 and X-330).

| Organics - Invertebrate Toxicity in Soil | | | |
|---|---|---|---|
| SWMU | Number of COCs Detected | Number with Benchmarks | Number Exceeding Benchmarks (% Evaluated) |
| X-230J3 | 22 | 1 | 0 (0%) |
| X-230J5 | 2 | 1 | 0 (0%) |
| X-326 | 0 | -- | ---- |
| X-330 | 0 | -- | ---- |
| X-530A | 31 | 5 | 2 (40%) |
| X-615 | 19 | 2 | 0 (0%) |
| X-740 | 15 | 1 | 0 (0%) |
| X-744N | 16 | 1 | 1 (100%) |
| X-744S | 22 | 2 | 0 (0%) |
| X-745C | 29 | 2 | 1 (50%) |
| X-2230N | 2 | 0 | ---- |
| X-6619 | 1 | 0 | ---- |
| BFS | 11 | 1 | 1 (100%) |
| DMRQ | 19 | 4 | 1 (25%) |
| WDD | 1 | 1 | 0 (0%) |

6.6.7.2.2 Analysis by SWMU

Following is a detailed SWMU by SWMU analysis in which SWMU-specific RME concentrations (as presented in Tables 6.279 to 6.300) were compared to the benchmarks presented in Tables 6.303 to 6.311. Unlike the quadrant-wide analysis, the RME concentrations for the SWMU by SWMU analysis were always the maximum detected concentration. Appendix H.11 (inorganic COCs) and Appendix H.12 (organic COCs) contain lists of detects and exceedences by SWMU.

X-230J3 West Environmental Sampling Building and Intermittent Containment Basin

Soil samples were taken at SWMU X-230J3. Twenty inorganic and 22 organic COCs were detected in X-230J3 soils. Fourteen inorganic COCs had maximum values below background and were not considered further in the analysis. Of the six inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for three, and two (chromium and zinc) were exceeded. Soil invertebrate benchmarks were available for two of the six inorganic COCs and there was one exceedence (chromium). Of the 22 organic COCs detected, plant toxicity benchmarks were available for 7, and 4 (acenaphthene, benzo(a)anthracene, benzo(a)pyrene, and dibenz[a,h]anthracene) were exceeded. A soil invertebrate benchmark was available for one organic COC and it was not exceeded. The quadrant-wide maximum soil levels for uranium, nitrobenzene, benzene, dibenzofuran, and 15 PAH compounds (acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, fluorene, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene, and pyrene) occurred in X-230J3. Nitrobenzene was the only chemical detected in soil unique to SWMU X-230J3.

X-230J5 West Holding Pond and Oil Separation Basin

Sediment and soil samples were taken at X-230J5. In sediment, 20 organic COCs and 21 inorganic COCs were detected. Benchmarks were available for 12 inorganic COCs and 8 (antimony, arsenic, barium, copper, iron, manganese, nickel, and zinc) were exceeded. For organic COCs, benchmarks were available for 17 COCs and 10 (anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, phenanthrene, and

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pyrene) were exceeded. The quadrant-wide maximum sediment values for antimony and 1,2,4-trichlorobenzene occurred at X-230J5. These two chemicals were unique to SWMU X-230J5 in sediment.

Eighteen inorganic and two organic COCs were detected in X-230J5 soils. All inorganic COCs had maximum concentrations below background levels and were not considered further in the analysis. For the two organic COCs detected, no plant toxicity benchmarks were available. Soil invertebrate benchmarks were available for one organic COC and it was not exceeded. No quadrant-wide maximum soil concentrations occurred at SWMU X-230J5 and no COCs in soil were unique to this SWMU.

X-326 Process Building

Soil samples were taken at SWMU X-326. Two inorganic COCs were detected in X-326 soils. No X-326 soil samples were analyzed for organic COCs. Both inorganic COCs had maximum concentrations below background and were not considered further in the analysis. No quadrant-wide maximum soil concentrations occurred at SWMU X-326 and no COCs in soil were unique to this SWMU.

X-330 Process Building

Soil samples were taken at SWMU X-330. Two inorganic COCs were detected in X-330 soils. No X-330 soil samples were analyzed for organic COCs. Both inorganic COCs had maximum concentrations below background and were not considered further in the analysis. No quadrant-wide maximum soil concentrations occurred at SWMU X-330 and no COCs in soil were unique to this SWMU.

X-530A Switchyard including X-530B Switch House; X-530C Test and Repair Building; X-530D Oil House; X-530E Valve House; X-530F Valve House; X-530G GCEP Oil Pumping Station

Soil samples were taken at SWMU X-530A and associated areas. Twenty-three inorganic and 31 organic COCs were detected in X-530A soils. Ten inorganic COCs had maximum concentrations below background and were not considered further in the analysis. Of the 13 inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for seven, and five (chromium, cobalt, iron, mercury, and zinc) were exceeded. Soil invertebrate benchmarks were available for three of the 13 inorganic COCs and there was one exceedence (chromium). Of the 31 organic COCs detected, plant toxicity benchmarks were available for 11, and 5 (2-chlorophenol, 2,4-dichlorophenol, benzo[a]anthracene, benzo[a]pyrene, and dibenz[a,h]anthracene) were exceeded. Soil invertebrate benchmarks were available for five organic COCs and there were two exceedences (phenol and 1,2,4-trichlorobenzene). The quadrant-wide maximum soil levels for 4 inorganic COCs (aluminum, fluoride, selenium, and zinc) and 10 organic COCs (1,1,1-trichloroethane, 1,1-dichloroethane, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dichlorophenol, 2-chlorophenol, 4-methylphenol, acenaphthylene, and phenol) occurred at X-530A. Selenium, 1,2-dichlorophenol, 1,4-dichlorobenzene, 1,1-dichloroethane, and 4-methylphenol were the only detected chemicals in soil unique to SWMU X-530A.

X-615 Abandoned Sanitary Sewage Treatment Facility

Soil samples were taken at SWMU X-615. Twenty-three inorganic and 19 organic COCs were detected at X-615 soils. Eleven inorganic COCs had maximum concentrations below background and were not considered further in the analysis. Of the 12 inorganic

COCs with maximum concentrations above background, plant toxicity benchmarks were available for 7, and 4 (cadmium, mercury, silver, and zinc) were exceeded. Soil invertebrate benchmarks were available for 4 of the 12 inorganic COCs and there was one exceedence (mercury). Of the 19 organic COCs detected, plant toxicity benchmarks were available for 6, and 2 (benzo[a]anthracene and benzo[a]pyrene) were exceeded. Soil invertebrate benchmarks were available for two organic COCs and there were no exceedences. The quadrant-wide maximum soil levels for four inorganic COCs (beryllium, cadmium, mercury and silver), one radionuclide COC (technetium), and one organic COC (Aroclor-1260) occurred at X-615. Silver was the only detected chemical in soil unique to SWMU X-615.

X-740 Waste Oil Handling Facility

Soil samples were taken at SWMU X-740. Twenty-two inorganic and 15 organic COCs were detected in X-740 soils. Twelve inorganic COCs had maximum concentrations below background and were not considered further in the analysis. Of the ten inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for seven, and five (antimony, arsenic, chromium, iron, and zinc) were exceeded. Soil invertebrate benchmarks were available for 4 of the 10 inorganic COCs and there was one exceedence (chromium). Of the 15 organic COCs detected, plant toxicity benchmarks were available for 3, and 2 (benzo[a]anthracene and benzo[a]pyrene) were exceeded. Soil invertebrate benchmarks were available for one organic COC and it was not exceeded. The quadrant-wide maximum soil levels for five inorganic COCs (antimony, arsenic, chromium, manganese, and vanadium) and two organic COCs (2-methylnaphthalene and trichloroethene) occurred at X-740. No detected chemical in soils was unique to SWMU X-740.

X-744N, X-744P, X-744Q Warehouse and Associated Oil Construction Headquarters Area

Soil samples were taken at SWMU X-744N and associated areas. Twenty-one inorganic and 16 organic COCs were detected in X-744N soils. Sixteen inorganic COCs had maximum concentrations below background and were not considered further in the analysis. Of the five inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for two, and both (lithium and zinc) were exceeded. Soil invertebrate benchmarks were available for one of the five inorganic COCs and it was not exceeded. Of the 16 organic COCs detected, plant toxicity benchmarks were available for 3, and 2 (benzo[a]pyrene and 4,4-DDT) were exceeded. Soil invertebrate benchmarks were available for one organic COC (1,2,4-trichlorobenzene) and it was exceeded. The quadrant-wide maximum soil levels for one inorganic COC (total cyanide) and four organic COCs (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and ethylbenzene) occurred at X-744N. Three chemicals (4,4'-DDD, 4,4'-DDE, and 4,4'-DDT) in soils were unique to SWMU X-744N.

X-744S, X-744T, X-744U Lithium Storage Warehouses

Soil samples were taken at SWMU X-744S and associated areas. Twenty-two inorganic and 22 organic COCs were detected in X-744S soils. Sixteen inorganic COCs had maximum concentrations below background and were not considered further in the analysis. Of the six inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for three, and two (lithium and zinc) were exceeded. Soil invertebrate benchmarks were available for one of the six inorganic COCs and it was not exceeded. Of the 22 organic COCs detected, plant toxicity benchmarks were available for 7, and 2 (benzo[a]pyrene and benzo[a]anthracene) were exceeded. Soil

invertebrate benchmarks were available for two organic COCs and neither was exceeded. The quadrant-wide maximum soil levels for one inorganic COC (lithium) and four organic COCs (1,1-dichloroethene, benzoic acid, chlorobenzene, and tetrachloroethene) occurred at X-744S. No detected chemicals in soils were unique to SWMU X-744S.

X-745C West Cylinder Storage Yard

Soil samples were taken at SWMU X-745C. Twenty-three inorganic and 29 organic COCs were detected in X-745C soils. Five inorganic COCs had maximum concentrations below background and were not considered further in the analysis. Of the 18 inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for 13, and 7 (arsenic, chromium, cobalt, iron, mercury, nickel, and zinc) were exceeded. Soil invertebrate benchmarks were available for 8 of the 18 inorganic COCs and one (chromium) was exceeded. Of the 29 organic COCs detected, plant toxicity benchmarks were available for 10, and 3 [benzo(a)pyrene, benzo(a)anthracene, and dibenz(a,h)anthracene] were exceeded. Soil invertebrate benchmarks were available for two organic COCs and one (phenol) was exceeded. The quadrant-wide maximum soil levels for six inorganic COCs (barium, calcium, cobalt, iron, magnesium, and nickel) and three organic COCs (4-chloro-3-methylphenol, Aroclor-1254, and cis-1,2-dichloroethene) occurred at X-745C. Aroclor-1254 and cis-1,2-dichloroethene in soils were unique to SWMU X-745C.

X-2230N West Holding Pond No. 2

Sediment, surface water, and soil samples were taken at X-2230N. In sediment, 17 organic COCs and 21 inorganic COCs were detected. Sediment benchmarks were available for 10 inorganic COCs and 7 (arsenic, barium, iron, manganese, mercury, nickel,

and zinc) were exceeded. For organic COCs, sediment benchmarks were available for 15 COCs and 4 (anthracene, benzo[g,h,i]perylene, chrysene, and 4-methylphenol) were exceeded. The quadrant-wide sediment maximum values for aluminum, carbon disulfide, and 4-methylphenol occurred at X-2230N. Carbon disulfide in sediment was unique to SWMU X-2230N.

In surface water, two inorganic COCs were detected; no organic chemicals were detected. For inorganic COCs, benchmarks were available for both chemicals and there was one exceedence (zinc). No quadrant-wide maximum surface water levels occurred at X-2230N and no chemicals in surface water were unique to this SWMU.

In soil, 17 inorganic and 2 organic COCs were detected in X-2230N soils. Fifteen inorganic COCs had maximum concentrations below background levels and were not considered further in the analysis. Of the two inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for both, and one (mercury) was exceeded. Soil invertebrate benchmarks were available for both inorganic COCs and there were no exceedences. For the two organic COCs detected, no plant or soil invertebrate toxicity benchmarks were available. The quadrant-wide maximum soil concentration for Aroclor-1248 occurred at X-2230N; this chemical in soil was unique to this SWMU.

X-6619, X-6614E Sewage Treatment Facility

Soil samples were taken at SWMU X-6619 and associated areas. Twenty inorganic and one organic COCs were detected in X-6619 soils. Fourteen inorganic COCs had maximum concentrations below background and were not considered further in the analysis. Of the 6 inorganic COCs with maximum concentrations above background, plant toxicity

benchmarks were available for 3, and one (arsenic) was exceeded. Soil invertebrate benchmarks were available for 2 of the 6 inorganic COCs; neither was exceeded. No plant toxicity or soil invertebrate benchmarks were available for the one organic COC (fluoranthene). The quadrant-wide maximum soil levels for 2 inorganic COCs (manganese and sodium) occurred at X-6619. No chemicals in soils were unique to X-6619.

Initial Construction Bulk Fuel Storage Area; X-7725 Recycle Assembly Building; and X-7745R Recycle Assembly Storage Yard (BFS)

Soil samples were taken at SWMU BFS and associated areas. Twenty-one inorganic and 11 organic COCs were detected in BFS soils. Ten inorganic COCs had maximum concentrations below background and were not considered further in the analysis. Of the 11 inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for 7, and 5 (arsenic, iron, lead, nickel, and zinc) were exceeded. Soil invertebrate benchmarks were available for 5 of the 11 inorganic COCs; none was exceeded. Of the 11 organic COCs detected, plant toxicity benchmarks were available for 2 and neither was exceeded. A soil invertebrate benchmark was available for one organic COC (phenol) and it was exceeded. The quadrant-wide maximum soil levels for one inorganic COC (copper) and two organic COCs (gamma-chlordane and heptachlor) occurred at BFS. Gamma-chlordane and heptachlor in soils were unique to SWMU BFS.

Don Marquis Substation, Associated Containment Ponds and Drainage Ditches (DMRQ)

Sediment, surface water, and soil samples were taken at DMRQ. In sediment, 2 organic COCs and 20 inorganic COCs were detected. Benchmarks were available for 10 inorganic COCs and 5 (arsenic, barium, iron, manganese, and zinc) were exceeded.

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Benchmarks were available for both organic COCs and neither was exceeded. The quadrant-wide sediment maximum values for calcium, magnesium, potassium, thallium, and chloroform occurred at DMRQ. Thallium and chloroform in sediment were unique to DMRQ.

In surface water, 22 inorganic and 6 organic COCs were detected. For inorganic COCs, benchmarks were available for 21 COCs and there were 17 exceedences (aluminum, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, vanadium, and zinc). For organic COCs, benchmarks were available for all 6 COCs and there were 2 exceedences (benzo[a]anthracene and pyrene). Quadrant-wide maximum surface water levels occurred at DMRQ for 20 inorganic COCs (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, vanadium, and zinc) and 6 organic COCs (benzo[a]anthracene, fluoranthene, phenanthrene, pyrene, isophorone, and 2-chlorophenol). Eleven inorganic COCs (antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, mercury, nickel, silver, and vanadium) and 4 organic COCs (2-chlorophenol, benzo[a]anthracene, pyrene, and isophorone) in surface water were unique to this SWMU.

In soil, 21 inorganic and 19 organic COCs were detected in DMRQ soils. Ten inorganic COCs had maximum concentrations below background levels and were not considered further in the analysis. Of the 11 inorganic COCs with maximum concentrations above background, plant toxicity benchmarks were available for 7, and 6 (antimony, chromium, cobalt, iron, lead, and zinc) were exceeded. Soil invertebrate benchmarks were available for 3 inorganic COCs and one (chromium) was exceeded. Of the 19 organic COCs detected, plant toxicity benchmarks were available for 8, and 2 (2-chlorophenol and 2,4-dichlorophenol) were exceeded. Soil invertebrate benchmarks were

available for 4 organic COCs and one (phenol) was exceeded. The quadrant-wide maximum soil concentrations for lead, potassium, bromodichloromethane, chloroform, styrene, and xylenes occurred at DMRQ. Bromodichloromethane and styrene in soil were unique to DMRQ.

West Drainage Ditch (WDD)

Sediment, surface water, and soil samples were taken at WDD. In sediment, 24 organic COCs and 23 inorganic COCs were detected. Benchmarks were available for 12 inorganic COCs and 11 (arsenic, barium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, and total cyanide) were exceeded. For organic COCs, benchmarks were available for 21 COCs and 14 (dibenzofuran, 2-methylnaphthalene, acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, naphthalene, phenanthrene, and pyrene) were exceeded. The quadrant-wide sediment maximum values for 18 inorganic COCs (aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, fluoride, iron, lead, manganese, mercury, nickel, sodium, vanadium, zinc, and total cyanide), 2 radionuclides (technetium and uranium), and 23 organic COCs (Aroclor-1260, dieldrin, dibenzofuran, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, trichloroethene, xylenes, and tetrachloroethene) occurred at WDD. Cyanide, dieldrin, trichloroethene, and tetrachloroethene in sediment were unique to WDD.

In surface water, 11 inorganic and 15 organic COCs were detected. For inorganic COCs, benchmarks were available for 10 COCs and there were 7 exceedences (aluminum,

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iron, lead, magnesium, potassium, sodium, and zinc). For organic COCs, benchmarks were available for 14 COCs and there was 1 exceedence (anthracene). Quadrant-wide maximum surface water levels occurred at WDD for 2 inorganic COCs (fluoride and sodium) and 13 organic COCs (anthracene, gamma-BHC, bromodichloromethane, chloroform, dibromochloromethane, 1,2-dibromo-3-chloropropane, 1,4-dioxane, ethylbenzene, isobutylalcohol, kepone, pentachlorophenol, O,O,O-triethylphosphorothioate, and xylene). These 13 organics in surface water were unique to WDD.

In soil, 19 inorganic COCs and one organic COC were detected in WDD soils. All inorganic COCs had maximum concentrations below background levels and thus were not considered further in the analysis. For the single organic COC detected (chlorobenzene), no plant toxicity benchmark was available. A soil invertebrate benchmark was available for chlorobenzene and it was not exceeded. No quadrant-wide maximum soil concentrations occurred at WDD and no chemical in soil was unique to this SWMU.

Summary

In summary, sediments were sampled at four SWMUs (WDD, DMRQ, X-230J5, and X-2230N). Benchmarks were available for most detected organic COCs but only for about half (10 of 23) of the detected inorganic COCs. The number of detected chemicals ranged from 22 (DMRQ) to 47 (WDD). One or more chemical exceeded benchmarks in each SWMU, with the number of exceedences ranging from 5 (DMRQ) to 25 (WDD). For inorganic COCs, arsenic barium, iron, manganese, and zinc exceeded benchmarks in all four SWMUs and the number of benchmark exceedences ranged from 5 (DMRQ) to 11 (WDD). For organic COCs, the number of exceedences ranged from zero (DMRQ) to 14 (WDD). Anthracene, benzo(g,h,i)perylene, and chrysene exceeded benchmarks most frequently (three of four SWMUs).

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Surface water was sampled at three SWMUs (DMRQ, X-2230N, and WDD). Benchmarks were available for almost all detected inorganic and organic chemicals. One or more chemicals exceeded benchmarks at each SWMU, with the number of exceedences ranging from one (X-2230N) to 19 (DMRQ). For inorganic COCs, zinc exceeded benchmarks at all 3 SWMUs and the number of benchmark exceedences ranged from one (X-2230N) to 17 (DMRQ). For organic COCs, all benchmark exceedences were for PAH compounds and the number of exceedences ranged from zero (X-2230N) to two (DMRQ).

Soils were sampled at 15 SWMUs. More COCs had available plant toxicity benchmarks than soil invertebrate toxicity benchmarks, although both types of benchmarks were unavailable for many chemicals. The number of detected chemicals ranged from 2 (X-326 and X-330) to 54 (X-530A). One or more chemicals exceeded plant toxicity benchmarks at 11 SWMUs and soil invertebrate toxicity benchmarks at 8 SWMUs. For inorganic COCs, the number of chemicals exceeding background ranged from zero (WDD, X-230J5, X-326, and X-330) to 18 (X-745C). The number of exceedences of plant toxicity benchmarks (for SWMUs with at least one inorganic COC detected above background) ranged from one (X-2230N and X-6619) to seven (X-745C); for soil invertebrate toxicity benchmarks, the range was zero (five SWMUs) to one (six SWMUs). Zinc exceeded plant toxicity benchmarks most frequently (9 of 15 SWMUs) and chromium exceeded soil invertebrate toxicity benchmarks most frequently (5 of 15 SWMUs). For organic COCs the number of detected chemicals ranged from zero (X-326 and X-330) to 31 (X-530A). The number of exceedences of plant toxicity benchmarks (for SWMUs with at least one detected organic that had a benchmark value) ranged from zero (BFS) to five (X-530A); eight SWMUs had at least one exceedence. For soil invertebrate toxicity benchmarks, the range was zero (six SWMUs) to two (X-530A); five SWMUs had at least one exceedence. Benzo(a)pyrene exceeded plant toxicity benchmarks most frequently (7 of 15 SWMUs) and phenol exceeded soil invertebrate toxicity benchmarks most frequently (4 of 15 SWMUs).

6.6.7.3 Magnitude of Exceedences

Tables 6.318 (sediment), 6.319 (surface water), 6.320 (plants), and 6.321 (soil invertebrates) summarize, by SWMU, the degree (magnitude) to which the maximum exposure levels for the COCs exceed the respective screening benchmarks for each environmental medium. Exceedences of screening benchmarks (ratios greater than one) infer a potential risk, indicating that further assessment of a particular chemical, medium, and/or SWMU may be warranted as part of a more detailed analysis, such as a BERA. In the following discussion, high exceedences and low exceedences refer to the relative magnitude of the exceedence (the degree to which the ratio exceeds one) and thus of the potential risk.

Sediment

Sediment was sampled at four SWMUs and all four had exceedences for inorganic COCs; all SWMUs except DMRQ also had exceedences for organic COCs (Table 6.318). WDD had the highest number of exceedences of both inorganic (11) and organic (14) sediment benchmarks. For inorganic COCs, the magnitude of exceedences (all SWMUs) ranged from 1.03 to 34. Iron had the highest exceedence ratio in three of the four SWMUs (X-230J5, X-2230N, and DMRQ). Cyanide (at WDD) had the highest exceedence ratio (34) of any inorganic COC. For organic COCs, the magnitude of exceedences (all SWMUs) ranged from 1.16 to 298,408. Anthracene had the highest exceedence ratio in all three SWMUs (X-230J5, X-2230N, and WDD) for which there were exceedences of organic sediment benchmarks. The highest exceedence ratio (298,408 for anthracene) occurred at WDD.

Surface Water

Surface water was sampled at three SWMUs and all three had exceedences for inorganic COCs; all SWMUs except X-2230N also had exceedences for organic COCs (Table 6.319). DMRQ had the highest number of exceedences of both inorganic (17) and organic (two) surface water benchmarks. For inorganic COCs, the magnitude of exceedences (all SWMUs) ranged from 3.05 to 118,462. Magnesium had the highest exceedence ratio in two of the three SWMUs (WDD and DMRQ), and magnesium (at DMRQ) also had the highest exceedence ratio (118,462) of any inorganic COC. Zinc, the only inorganic surface water COC to exceed its surface water benchmark at X-2230N, had a relatively low exceedence ratio (3.05).

For organic COCs, the magnitude of exceedences (all SWMUs) ranged from 25.7 to 1,250. Anthracene was the only organic COC to exceed its benchmark at WDD, with an exceedence ratio of 1,250 (the highest exceedence ratio of all organic surface water COCs). Benzo(a)anthracene had the highest surface water exceedence ratio (54.5) at DMRQ. No organic COCs in surface water exceeded benchmarks at X-2230N.

Soil - Toxicity to Plants

Soil was sampled at 15 SWMUs and all but 4 (WDD, X-230J5, X-326, and X-330) had exceedences of inorganic plant toxicity benchmarks (Table 6.320). For inorganic COCs, X-745C had the highest number of exceedences (seven). The magnitude of exceedences (all SWMUs) ranged from 1.15 to 7,100. Iron had the highest exceedence ratio at five SWMUs (X-530, X-745C, X-740, BFS, and DMRQ), whereas lithium (X-744S and X-744N) and mercury (X-615 and X-2230N) each had the highest exceedence ratio at

For organic COCs, 8 of 15 SWMUs had at least one exceedence of plant toxicity benchmarks (Table 6.320). X-530A had the highest number (five) of exceedences. The magnitude of exceedences (all SWMUs) ranged from 3.38 to 104,348. Benzo(a)anthracene had the highest exceedence ratio at five SWMUs (X-745C, X-740, X-615, X-230J3, and X-744S), whereas 2,4-dichlorophenol had the highest exceedence ratio at 2 SWMUs (X-530A and DMRQ). Benzo(a)anthracene (at X-230J3) had the highest exceedence ratio (104,348) of any organic COC.

Soil - Toxicity to Invertebrates

Of the 15 SWMUs sampled for soil, only 6 (X-530A, X-745C, DMRQ, X-615, X-230J3, and X-740) had exceedences of inorganic soil invertebrate toxicity benchmarks (Table 6.321), although it should be noted that benchmark values were unavailable for many chemicals. All six SWMUs had a single exceedence and the magnitude of exceedences (all SWMUs) ranged from 5 to 18.5. Chromium had the highest exceedence ratio at five of the six SWMUs, with mercury (at X-615) having the highest exceedence ratio at the sixth SWMU. Chromium (at X-740) had the highest exceedence ratio (18.5) of any inorganic COC.

For organic COCs, only five SWMUs had at least one exceedence of a soil invertebrate toxicity benchmark (Table 6.321), although it should be noted that benchmark values were unavailable for many chemicals. X-530A had the highest number (two) of exceedences. The magnitude of exceedences (all SWMUs) was relatively high, ranging from 558 to 390,000. Phenol had the highest exceedence ratio at three SWMUs (X-745C, DMRQ, and BFS) and 1,2,4-trichlorobenzene had the highest exceedence ratio at the remaining two SWMUs (X-530A and X-744N). 1,2,4-trichlorobenzene (at X-530A) had the highest exceedence ratio (390,000) of any organic COC; this was the highest

exceedence of a benchmark in any Quadrant III SWMU for any COC in any of the environmental media sampled.

6.6.7.4 Analysis by Watershed

The exceedences for individual SWMUs discussed are in Section 6.6.7.2. There are three watersheds, or integrator units, in Quadrant III (Table 6.273). In the watershed analysis, individual samples taken within SWMUs that drain to more than one watershed were evaluated to determine which watershed could potentially receive inputs from COCs which exceeded screening benchmarks. Only one SWMU (X-744N) in Quadrant III drains to more than one watershed.

For inorganic COCs, X-744N had two plant benchmark exceedences (lithium and zinc). Lithium exceeded its plant benchmark in one sample, X744N-HA06, which drains to watershed "C". Zinc also exceeded its plant benchmark in only one sample, X744N-HA04, which drains to watershed "B".

For organic COCs, 2 COCs exceeded plant benchmarks in soil at X-744N (4,4'-DDT and benzo[a]pyrene), and one COC exceeded its invertebrate benchmark in soil (1,2,4-trichlorobenzene). 4,4'-DDT concentrations exceeded plant benchmarks in two samples, X744N-HA01 and X744N-HA05, both of which drain into watershed "B". Benzo[a]pyrene concentrations exceeded plant benchmarks in a total of four samples; three that drain to watershed "B" (X744N-HA01, X744N-HA04, and X744N-HA05) and one that drains to watershed "C" (X744N-HA06). 1,2,4-Trichlorobenzene exceeded its invertebrate benchmark in one sample, X744N-HA02, which drains to watershed "C".

### 6.6.8 Conclusions

The purpose of this PERA was to assemble the existing information on: (1) the general ecology of Quadrant III; (2) the likely exposure pathways and receptors in the area; and (3) the fate, exposure levels, and ecotoxicity of the chemicals detected in surface water, sediment, and soil. The PERA analysis is intended to screen the COCs with regard to their potential ecological risks and their likely SWMU sources. The results of the PERA provide a basis to focus subsequent analysis, such as a facility-wide and watershed-based BERA.

#### 6.6.8.1 General Conclusions

Quadrant III of PORTS contains 19 SWMUs, 15 of which were considered in this PERA. Soil (0-2 ft depth only), sediment, and surface water samples were analyzed for a variety of inorganic and organic chemicals and radionuclides. These chemical analyses form the basis of the exposure estimates for ecological receptors, including sensitive aquatic species, and terrestrial plants and soil invertebrates. Calculated RME concentrations were compared to screening benchmarks (i.e., adverse effect levels either promulgated/proposed by various regulatory agencies or derived from available toxicity data) to determine if there is a potential risk to ecological receptors. Based on this screening analysis, conducted for individual SWMUs, as well as for the quadrant as a whole, the following conclusions and further considerations are presented:

- As a screening method, the PERA is based on the use of conservative ecotoxicological benchmarks that are compared to "upper bound" (i.e., 95% UCL or maximum) environmental levels of the various COCs. Therefore, if a COC does not exceed a benchmark, it is probable that the ecological risk from this COC is

negligible. Conversely, an exceedence does not necessarily mean that a risk exists, but does suggest that further evaluation may be warranted.

- Both quadrant-wide and SWMU-by-SWMU risks were evaluated in this PERA. Quadrant-wide RME concentrations (represented by the 95% UCL on the mean or the maximum detected level, whichever is less) for each COC were compared to benchmark values (Table 6.317). SWMU-specific RME concentrations (represented as the maximum detected level) for each COC were compared to the same benchmark values (Appendices H.11 and H.12).

- Three watersheds were identified within Quadrant III. One SWMU drains to watershed "A," 14 drain at least partially to watershed "B," and one drains partially to watershed "C." One SWMU (X-744N) drains to more than one watershed. Exceedences of at least one available benchmark in each environmental medium sampled were observed for all three watersheds.

- Twenty-six inorganic COCs, 60 organic COCs, and 2 radionuclides were detected in at least one environmental medium (sediment, surface water, and 0-2 ft soil).

    - Twenty-one of the 26 inorganic COCs were detected in all three media. Twenty-three of 26 inorganic COCs were found in sediment, 22 of 26 were found in surface water, and 25 of 26 were detected in soil.

    - Seven organic COCs were detected in all three media (anthracene, benzo[a]anthracene, chloroform, fluoranthene, phenanthrene, pyrene, and xylene). Twenty-seven of the 60 organic COCs were detected in sediment, 19 of 60 were detected in surface water, and 49 of 60 were detected in soil.

- Uranium and technetium were detected in sediment and soil, but not in surface water.

- Tentative background levels were available for 21 of 25 inorganic COCs detected in soil (all except antimony, cyanide, lithium, and selenium). The quadrant-wide RME levels were less than background for 17 of these 21 inorganic COCs (Table 6.277). The four remaining inorganic COCs (calcium, magnesium, silver, and sodium) (Table 6.275) often exceeded background. Uranium was present in some soil samples at concentrations above background. No background level exists for technetium since it is not a naturally occurring compound. There were no background levels for inorganic COCs or radionuclides COCs in sediment or surface water. There were no tentative background levels available for organic COCs.

- There were a number of COCs for which screening benchmarks were not available for a given medium (see Table 6.313). Benchmarks were available for 13 of 23 detected inorganic COCs and 24 of 27 organic COCs in sediment. Benchmarks were available for 21 of 22 detected inorganic COCs and 18 of 19 detected organic COCs in surface water. Phytotoxicity benchmarks were available for 17 of 22 inorganic COC for which the maximum concentrations were above tentative background (SWMU by SWMU analysis); three of eight inorganic COCs for which the RME concentrations were above background (quadrant-wide analysis); and 17 of 49 organic COCs in soil. Benchmarks for soil invertebrate toxicity were available for eight of 22 inorganic COCs for which the maximum concentrations were above preliminary background (SWMU by SWMU analysis); zero of eight inorganic COCs for which the RME concentrations were above background (quadrant-wide analysis); and six of 49 organic COCs in soil. No screening

benchmarks were available for radionuclides in any environmental medium. There were no SWMUs for which benchmarks were available for all detected COCs.

- Table 6.312 lists 38 organic COCs (out of 60 detected) that have a log $K_{ow}$ of 3 or higher and that may have the potential to bioaccumulate through the foodchain. A $K_{ow}$ value for O,O,O-triethylphosphorothioate was not available. Screening benchmarks were not available for bioaccumulation of metals or for bio-uptake of any COCs into higher plants. However, some heavy metals are known to be taken up by plants and organic forms of certain metals bioaccumulate in the foodchain (e.g., organo-mercury and organo-lead complexes).

6.6.8.2 Conclusions Related to the Quadrant-Wide Analysis

The quadrant-wide analysis separates those COCs that pose negligible risk to ecological receptors from those that may pose a risk based on a comparison of the RME concentration across the quadrant with suitable screening benchmark values. The potential for risk is further defined by medium (surface water, sediment, and soil). At the PERA level of analysis, the quadrant-wide magnitude of exceedence was not considered.

Results of the quadrant-wide screen indicate that a potential ecological risk exists for 15 organic COCs (Table 6.317); they include 11 organic COCs in sediment, 3 organic COCs in surface water, and 8 organic COCs in soil (6 as a result of exceeding phytotoxicity benchmarks and 2 as a result of exceeding soil invertebrate toxicity benchmarks). Ten of the 60 organic COCs may be dropped from further consideration because their RME levels were below all available benchmarks in the media in which they were detected. They are: dieldrin, carbon disulfide, dibromochloromethane, 1,2-dibromo-3-chloropropane, 1,4-dioxane, isobutyl alcohol, isophorone, kepone, pentachlorophenol,

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and gamma-BHC. The remaining 36 organic COCs did not have exceedences, but also did not have a complete set of benchmarks and therefore could not be fully screened.

A potential ecological risk exists for 20 inorganic COCs (Table 6.317). Seven inorganic COCs exceeded a benchmark in sediment, 17 exceeded a benchmark in surface water, and lithium exceeded a benchmark for phytotoxicity (none exceeded soil invertebrate benchmarks). None of the inorganic COCs that were above background levels were dropped from further consideration based on the PERA analysis.

An analysis of potential ecological risks associated with radionuclides was performed by comparing Quadrant III uranium and technetium concentrations in soil, surface water, and sediment to the concentrations calculated in the Phase I Quadrant I/II RFIs, for which a quantitative assessment of radionuclide risks was undertaken. This analysis suggests that Quadrant III radionuclide concentrations should not pose a significant risk to ecological receptors.

6.6.8.3 Conclusions Related to the SWMU by SWMU Analysis

The PERA analysis of data for individual SWMUs provides a means of focusing further analysis on certain SWMUs for which potential risks may be higher and identifying sources of COCs. The table below provides a ranking of the SWMUs by their total number of exceedences and may be useful for prioritizing analysis in a more rigorous assessment, such as a BERA. An exceedence occurred in every SWMU where benchmarks were available for comparison.

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**Unique COCs for Which No Benchmarks were Available[1]**

| SWMU | COC | Environmental Medium | | | |
|---|---|---|---|---|---|
| | | Sediment | Surface Water | Soil (Plants) | Soil (Invertebrates) |
| X-230J3 | Nitrobenzene | | | X[1] | X |
| X-530A | 1,1-Dichloroethane | | | X | X |
| | Selenium | | | X | X |
| X-744N | 4,4'-DDD | | | X | X |
| | 4,4'-DDE | | | X | X |
| X-745C | cis-1,2-Dichloroethene | | | X | X |
| X-2230N | Aroclor-1248 | | | X | X |
| BFS | gamma-Chlordane | | | X | X |
| | Heptachlor | | | X | X |
| DMRQ | Thallium | X | | | |
| | Bromodichloromethane | | | X | X |
| | Styrene | | | X | X |
| WDD | O,O,O-Triethylphosphorothioate | | X | | |

[1] X = COC was detected only once in the indicated medium, but no benchmark was available for the COC in that medium.

- Two SWMUs, WDD (58 maximum values) and DMRQ (37 maximum values) accounted for 56 percent (95 of 177) of the maximum detected levels for all COCs in all media combined (Tables 6.301 and 6.302).

- The COCs with the highest number of screening benchmark exceedences in the SWMU by SWMU analysis are provided in the table below. Among inorganic COCs, zinc had the greatest number of exceedences with 16 (combining all three media), followed by chromium with 12 exceedences, and iron with 11 exceedences. Among organic COCs, both

benzo(a)anthracene and benzo(a)pyrene had nine exceedences. Dibenz(a,h)anthracene was third highest among organic COCs with five exceedences.

- Although magnitude of exceedence is not a deciding factor in the PERA analysis, it can provide information useful to a more detailed assessment, such as a BERA. Among inorganic COCs, the highest magnitudes of exceedence were for cyanide in sediment, magnesium in surface water, and iron in soil. Among organic COCs, the highest magnitudes of exceedence were for anthracene in sediment and surface water, and 1,2,4-trichlorobenzene in soil. The magnitudes of exceedence for all COCs are listed in Table 6.318 to 6.321.

**COCs with Exceedences and Number of SWMUs in Each Medium Where Exceedences Occurred**

| Constituent | Sediment | Surface Water | Soil (Plants) |
|---|---|---|---|
| INORGANICS | | | |
| Aluminum | 0 | 2 | --[1] |
| Antimony | 1 | 0 | 2 |
| Arsenic | 4 | 1 | 4 |
| Barium | 4 | 0 | 0 |
| Beryllium | 0 | 1 | 0 |
| Cadmium | 0 | 1 | 1 |
| Chromium | 1 | 1 | 10 |
| Cobalt | 0 | 1 | 3 |
| Copper | 2 | 1 | 0 |
| Cyanide | 1 | -- | 0 |
| Iron | 4 | 2 | 5 |

| COCs with Exceedences and Number of SWMUs in Each Medium Where Exceedences Occurred | | | |
|---|---|---|---|
| **Constituent** | **Sediment** | **Surface Water** | **Soil (Plants)** |
| Lead | 1 | 2 | 2 |
| Lithium | -- | -- | 3 |
| Magnesium | 0 | 2 | 0 |
| Manganese | 4 | 1 | -- |
| Mercury | 2 | 1 | 5 |
| Nickel | 3 | 1 | 2 |
| Potassium | 0 | 2 | 0 |
| Silver | -- | 1 | 1 |
| Sodium | 0 | 1 | 0 |
| Vanadium | 0 | 1 | 0 |
| Zinc | 4 | 3 | 9 |
| ORGANICS | | | |
| Acenaphthene | 1 | -- | 1 |
| Anthrancene | 3 | 1 | 0 |
| Benzo(a)anthracene | 2 | 1 | 6 |
| Benzo(a)pyrene | 2 | -- | 7 |
| Benzo(g,h,i)perylene | 3 | -- | 0 |
| Benzo(k)fluoranthene | 2 | -- | -- |
| 2-Chlorophenol | -- | 0 | 2 |
| Chrysene | 3 | -- | 0 |
| 4,4'-DDT | -- | -- | 1 |
| Dibenz(a,h)anthracene | 2 | -- | 3 |
| Dibenzofuran | 1 | -- | 0 |
| 2,4-Dichlorophenol | -- | -- | 2 |
| Fluoranthene | 2 | 0 | 0 |
| 2-Methylnaphthalene | 1 | -- | 0 |

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| COCs with Exceedences and Number of SWMUs in Each Medium Where Exceedences Occurred | | | |
|---|---|---|---|
| **Constituent** | **Sediment** | **Surface Water** | **Soil (Plants)** |
| 4-Methylphenol (p-cresol) | 1 | -- | 0 |
| Naphthalene | 1 | -- | 0 |
| Phenanthrene | 2 | 0 | 0 |
| Phenol | -- | -- | 4 |
| Pyrene | 2 | 1 | 0 |
| 1,2,4-Trichlorobenzene | 0 | -- | 2 |
| [1] -- = Chemical not detected in this medium. | | | |

Based on the PERA analysis, the following should be considered when determining the necessity for, and the scope of, more detailed analysis:

- A review of available data suggests that the terrestrial and aquatic habitats in Quadrant III may support numerous types of wildlife indigenous to southcentral Ohio. A more intensive survey of the habitat in Quadrant III would be needed to determine whether it can support the threatened and endangered species listed in Table 6.274 and Appendix H.9.

- One-hundred and sixteen of 244 potential comparisons between exposure estimates and screening benchmarks could not be made because benchmarks and/or toxicity data were unavailable. Information is needed to develop screening benchmarks for these chemicals and media as part of more detailed analysis (possibly using "surrogate compounds" for which toxicity data are available).

- There were many instances in which the maximum measured level of a particular inorganic COC was below its tentative soil background level but above the derived benchmark. The derivation and validity of these soil benchmarks, as well as that of the background analyses, need further examination.

- There were a number of instances where plant benchmarks are based on nutrient solution values because soil concentrations were not available. Soil benchmarks based on nutrient solution are more conservative than those based on soil concentrations, and the uncertainty about these benchnmarks is considered greater than about those based on soil concentrations.

- Fraction organic carbon data (Foc) in sediment were not available for use in the PERA. Therefore, a value of 4% organic carbon was assumed based on Mackay et al. (1992). Because Foc is used to estimate sediment benchmarks, an assumed value of 4% organic carbon may either under or overestimate benchmark values for PORTS, depending on whether the actual Foc in PORTS sediments is lower or higher than that assumed here.

## 6.7 Risk-Based Remedial Action Objectives (RAOs)

### 6.7.1 Introduction

The purpose of this section is to develop human health risk-based remedial action objectives (RAOs), which can be used as chemical-specific concentration targets during the analysis and selection of remedial alternatives at the PORTS facility.

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RAOs are chemical-specific concentrations in a given medium and for a specific land use (or exposure scenario) that correspond to a noncancer HI of one and excess cancer risks of $10^{-4}$ and $10^{-6}$ for all exposure pathways combined for that medium. These RAOs are similar to the preliminary remediation goals (PRGs) described in RAGS Part B (U.S. EPA, 1991b). Both RAOs and PRGs are concentration goals for individual chemicals for specific medium and land use combinations. However, RAOs, as developed for the PORTS facility, and PRGs differ in two significant ways. Whereas PRGs have been developed for only a limited number of potential exposure pathways (see U.S. EPA, 1991b, Exhibit 2-1), RAOs have been developed based on all the exposure pathways considered in the BRA for Quadrant III of PORTS. Also, PRGs may be based on either applicable or relevant and appropriate requirements (ARARs) or on risk-based calculations, whereas RAOs, as defined here, are risk-based only. It is important to note that RAOs, like PRGs, are targets only and do not establish that clean-up to these levels is necessarily warranted.

RAOs specific to ecological endpoints have not been developed as part of this RFI. The ecological benchmarks developed in the PERA are to be used for purposes of screening only, and are not intended to serve as target clean-up levels. Preliminary remedial action goals (PRGs) have been developed in the BERA for the reaches of Upper Little Beaver Creek and Big Run Creek (ORNL, 1994b). The reader is referred to the BERA for further discussion of PRGs based on ecological considerations.

The remainder of this section presents the methodology for calculating human health RAOs at PORTS through use of examples, identifies RAOs for the chemicals and radionuclides present in media at the PORTS facility that pose the greatest potential risks to human health, and provides observations on the alternative RAOs developed under different land use (exposure) scenarios.

### 6.7.2 Methodology for Calculating RAOs

The development of RAOs parallels the quantitative assessment of risks in the human health BRA for the PORTS facility. The RAOs have been calculated for chemicals of potential concern present in groundwater, soil, sediment, and surface water at PORTS. These chemicals of potential concern in the various media are identified in Section 6.2. The exposure scenarios and pathways considered in the development of RAOs are those outlined in Section 6.3 and summarized in Section 6.7.2.1 below. The toxicity values used to calculate RAOs are provided in Section 6.4.

#### 6.7.2.1 Exposure Scenarios for RAOs

For the various media, RAOs have been calculated based on the same potential current and future on-site land uses considered in the BRA (i.e., worker, resident, excavation worker, and recreational population). The exposure pathways used to calculate RAOs are summarized in the following table.

| Exposure Pathways for the Development of RAOs | | | | |
|---|---|---|---|---|
| | Population | | | |
| Media | Worker | Resident | Excavation Worker | Recreational Population |
| Groundwater | Ingestion<br>Dermal contact<br>Inhalation of vapors | Ingestion<br>Dermal contact<br>Inhalation of vapors | - | - |

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| | | | | |
|---|---|---|---|---|
| Soil | Ingestion<br>Dermal contact<br>External radiation<br>Inhalation of vapors | Ingestion<br>Dermal contact<br>External radiation<br>Inhalation of vapors<br>Ingestion of vegetables<br>Ingestion of beef<br>Ingestion of milk | Ingestion<br>Dermal contact<br>External radiation<br>Inhalation of vapors<br>Inhalation of particulates | Game |
| Sediment | Ingestion<br>Dermal contact | - | - | Ingestion<br>Dermal contact |
| Surface Water | Ingestion<br>Dermal contact | - | - | Ingestion<br>Dermal contact |

### 6.7.2.2 Equations for Calculating RAOs

Risk-based RAOs are calculated by solving the risk equations for the concentration term. Because the equations used to calculate risks from noncarcinogens, chemical carcinogens, and the carcinogenic effects of radionuclides differ (see Section 6.5.2), the general procedures for calculating RAOs for each of these classes of compounds are presented below. The procedures for calculating RAOs are illustrated by the equation for calculating potential risk via ingestion of groundwater by a residential population.

In these equations, the target excess cancer risk is typically set at $10^{-4}$ to $10^{-6}$ and the target HQ is set at 1. Because risk is generally linear with respect to exposure concentration, the RAO for a target excess cancer risk of $10^{-4}$ would be two orders of magnitude greater than the RAO calculated for a target excess cancer risk of $10^{-6}$. RAOs are calculated to be protective of noncarcinogenic and carcinogenic effects independently; therefore, where a noncancer RfD and a cancer SF have been developed for a single chemical, the smaller of the two RAO values is selected.

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6.7.2.2.1 RAO Equation for Noncarcinogens

The RAO for a noncarcinogen is calculated by combining the appropriate oral RfD or inhalation RfC with the intake, setting the HQ equal to one, and solving the equation for the concentration term. This procedure is illustrated below for the pathway of residential ingestion of groundwater.

$$HQ = \frac{Intake\ from\ oral\ ingestion}{RfD_o} = \frac{CW \times IR \times EF \times ED}{RfD_o \times BW \times AT}$$

$$CW = \frac{HQ \times RfD_o \times BW \times AT}{IR \times EF \times ED}$$

| Parameters | Definition | RME Value |
|---|---|---|
| HQ | Hazard Quotient (unitless) | 1 |
| $RfD_o$ | Oral Reference Dose (mg/kg/day) | chemical specific |
| CW | Chemical concentration in groundwater (mg/L) | - |
| IR | Ingestion rate (L/day) | 2 |
| EF | Exposure frequency (days/yr) | 350 |
| ED | Exposure duration (yrs) | 30 |
| BW | Body weight (kg) | 70 |
| AT | Averaging time (days) | 10,950 |

6.7.2.2.2 RAO Equation for Chemical Carcinogens

The RAO for a chemical carcinogen is calculated by combining the appropriate oral cancer slope factor or inhalation unit risk with the intake, setting a target excess cancer risk level, and solving the equation for the concentration term. This procedure is illustrated below, as before, with the pathway of residential ingestion of groundwater.

$$Risk = SF_o \times Intake\ from\ ingestion\ of\ water = \frac{SF_o \times CW \times IR \times EF \times ED}{BW \times AT}$$

$$CW = \frac{Risk \times BW \times AT}{SF_o \times IR \times EF \times ED}$$

| Parameters | Definition | RME Value |
|---|---|---|
| Risk | Target excess cancer risk (unitless) | $10^{-4}$ to $10^{-6}$ |
| $SF_o$ | Oral cancer SF $(mg/kg/day)^{-1}$ | chemical specific |
| CW | Chemical concentration in groundwater (mg/L) | - |
| IR | Ingestion rate (L/day) | 2 |
| EF | Exposure frequency (days/yr) | 350 |
| ED | Exposure duration (yrs) | 30 |
| BW | Body weight (kg) | 70 |
| AT | Averaging time (days) | 25,550 |

6.7.2.2.3 RAO Equation for Radionuclides

The RAO for the carcinogenic effect of a radionuclide is calculated by combining the appropriate cancer SF with the intake, setting a target excess cancer risk level, and solving the equation for the concentration term. This procedure is illustrated below, as before, with the pathway of residential ingestion of groundwater.

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$$Risk = SF \times Intake = SF \times AW \times IR \times EF \times ED$$

$$AW = \frac{Risk}{SF \times IR \times EF \times ED}$$

| Parameters | Definition | RME Value |
|---|---|---|
| Risk | Target excess cancer risk (unitless) | $10^{-4}$ to $10^{-6}$ |
| SF | Cancer SF $(pCi)^{-1}$ | chemical specific |
| AW | Concentration in groundwater (pCi/L) | - |
| IR | Ingestion rate (L/day) | 2 |
| EF | Exposure frequency (days/yr) | 350 |
| ED | Exposure duration (yrs) | 30 |

### 6.7.2.2.4 RAO Equation for Multiple Exposure Pathways

Under most land use scenarios, potential risks associated with a given medium (e.g., groundwater or soil) are due to exposure via multiple pathways. For example, exposure to groundwater under the residential scenario could occur via ingestion, dermal contact, and inhalation of volatile constituents while showering. RAOs are therefore calculated by considering the cumulative exposure resulting from all potential exposure pathways evaluated quantitatively in the BRA. The procedure for calculating RAOs involving more than one exposure pathway is illustrated below for residential use of groundwater, and specifically, for chemical carcinogens present in groundwater. Equations can be similarly developed for noncarcinogens and radionuclides.

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*Total Risk from Water = Risk from ingestion of water + Risk from dermal contact with water (showering) + Risk from inhalation of volatiles (showering)*

$$= (SF_o \times CW \times EF_o) + (SF_d \times CW \times EF_d) + (SF_i \times CW^* \times EF_i)$$

$$= CW\,[(SF_o \times EF_o) + (SF_d \times EF_d) + (SF_i \times EF_i)]$$

$$CW = \frac{Total\ Risk}{(SF_o \times EF_o) + (SF_d \times EF_d) + (SF_i \times EF_i)}$$

| | | | |
|---|---|---|---|
| where: | CW | = | Concentration in groundwater (mg/L) |
| | $CW^*$ | = | Air concentration as a function of groundwater concentration (see Appendix H.7) |
| | Risk | = | Target excess cancer risk |
| | $SF_o$ | = | Oral cancer SF $(mg/kg\text{-}day)^{-1}$ |
| | $SF_d$ | = | Dermal cancer SF $(mg/kg\text{-}day)^{-1}$ |
| | $SF_i$ | = | Inhalation cancer unit risk $(\mu g/m^3)^{-1}$ |
| | $EF_o$ | = | Oral exposure factors [(IR x EF x ED)/(BW x AT)] |
| | $EF_d$ | = | Dermal exposure factors [(SA x PC x ET x EF x ED)/(BW x AT)] |
| | $EF_i$ | = | Inhalation exposure factors [(FE x EF x ED)/AT] |
| | IR | = | Ingestion rate (L/day) |
| | SA | = | Skin surface area available for contact ($cm^2$) |
| | PC | = | Dermal permeability coefficient (cm/hr) |
| | ET | = | Exposure time (hrs/day) |
| | FE | = | Fraction of day exposed (unitless) |
| | EF | = | Exposure frequency (days/yr) |
| | ED | = | Exposure duration (yrs) |
| | BW | = | Body weight (kg) |
| | AT | = | Averaging time (days) |

6.7.2.2.5 Alternative Methodology for Calculating RAOs

Because risks are directly proportional to intake, and thereby, concentration, the following ratio applies for a given chemical:

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$$\frac{\textit{Risk at concentration X}}{\textit{concentration X}} = \frac{\textit{Risk at concentration Y}}{\textit{concentration Y}}$$

Once a concentration and its corresponding risk are known, this ratio can be used to calculate the RAO for a target risk. Because the risks associated with a unit concentration have been calculated as part of the BRA, the above ratio can be modified to take the following form:

$$\frac{\textit{"Unit" Risk}}{\textit{Unit Concentration}} = \frac{\textit{Target Risk}}{\textit{RAO (for a single exposure pathway)}}$$

$$\textit{RAO (for a single exposure pathway)} = \frac{\textit{Target Risk}}{\textit{"Unit" Risk}} \times \textit{Unit Concentration}$$

where:

| | | |
|---|---|---|
| Target Risk | = | Excess cancer risk (e.g, $10^{-4}$ or $10^{-6}$) or noncancer HQ of 1 (unitless) |
| "Unit" Risk | = | Excess cancer risk or HQ associated with a unit concentration (unitless) |
| Unit Concentration | = | Concentration in the environmental medium of concern (i.e., 1 mg/L in water, or 1 mg/kg in soil or sediment) |

This ratio approach, which was used to calculate the RAOs in this assessment, is mathematically equivalent to the approach described in Sections 6.7.2.2.1 to 6.7.2.2.4. Application of the ratio approach is illustrated below for carcinogens and noncarcinogens.

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If the excess cancer risk for a given chemical and given exposure pathway associated with a unit concentration (1 mg/kg) in soil is $2 \times 10^{-5}$, the RAO associated with a target excess cancer risk of $10^{-6}$ is calculated as:

$$RAO = \frac{10^{-6}}{2 \times 10^{-5}} \times 1\ mg/kg = 0.05\ mg/kg$$

Similarly, for a HQ of $3 \times 10^{-2}$ associated with a unit groundwater concentration (1 mg/L), the RAO associated with a target HQ of 1 is calculated as:

$$RAO = \frac{1}{3 \times 10^{-2}} \times 1\ mg/L = 33\ mg/L$$

The above equations apply to single exposure pathways only. To develop an RAO that takes into consideration all relevant pathways, the RAO for a given population and a given medium can be determined from the following equation:

$$Risk\text{-}based\ RAO = \left( \frac{1}{RAO_o} + \frac{1}{RAO_d} + \frac{1}{RAO_i} + \ldots + \frac{1}{RAO_n} \right)^{-1}$$

| | | | |
|---|---|---|---|
| where: | $RAO_o$ | = | target concentration based on the oral pathway |
| | $RAO_d$ | = | target concentration based on the dermal contact pathway |
| | $RAO_i$ | = | target concentration based on the inhalation pathway |
| | $RAO_n$ | = | target concentration based on the $n^{th}$ pathway |

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### 6.7.3 Summary of Risk-Based RAOs for Driver Chemicals and Radionuclides

RAOs are presented in Tables 6.322 to 6.325 for the "driver" chemicals in the various media as identified in Section 6.5 (i.e., chemicals and radionuclides with excess cancer risks greater than $10^{-6}$ or HQ values of one or greater). Detailed tables listing the RAOs for all the chemicals detected in the various media can be found in Appendix H.13.

### 6.7.4 Conclusions and Observations

It is important to note that RAOs are calculated for individual chemicals by exposure medium and by exposure pathway. RAOs do not account for potential cumulative effects of exposure to multiple chemicals in a single medium, nor to exposure to a single chemical in multiple media. Also, RAOs are based solely on the protection of human health; potential ecological effects are not considered in the development of RAOs. It should be further noted that RAOs were derived without consideration for analytical detection limits. In fact, the RAOs for some chemicals (e.g., PCBs) are lower than available methods can detect. PQLs to which RAOs can be compared are found in Section 6.2.4.

Upon inspection of the tables in Appendix H.13, the following observations can be made:

- For constituents for which both a noncancer RfD and cancer SF have been developed, the RAO calculated using a target excess cancer risk of $10^{-6}$ is, in all cases, lower than the RAO calculated using a noncancer HQ of 1. Where the target excess cancer risk is set at $10^{-4}$, the RAO based on the analysis of noncancer effects is sometimes lower. Therefore, while

application of RAOs based on carcinogenic effects are generally protective, consideration should also be given to RAOs based on noncancer effects.

Groundwater

- RAOs for groundwater have been developed for both worker and residential exposure scenarios. Because the residential scenario results in greater potential exposures, the RAOs for the residential scenario are smaller than those for the worker scenario.

- The RAOs for the majority of the chemical constituents are driven by ingestion, assuming the groundwater to be a potential future drinking water source. For a few volatile chemicals, inhalation of vapors (during showering) is a significant exposure pathway. In fact, for chloroform, inhalation of vapors is the dominant pathway in determining the groundwater RAO.

Soil

- RAOs for soil have been developed for worker, residential, excavation worker, and recreational exposure scenarios. For most chemicals, the RAOs for residential land use conditions are the lowest. For those constituents that are relatively lipid soluble (e.g., PCBs, PAHs, and the pesticides gamma-chlordane, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT) and for some inorganic compounds, notably fluoride, mercury, selenium, silver, and technetium, inclusion of the beef and milk ingestion pathways substantially reduces the RAOs. For example, for Aroclor-1260, the inclusion of the beef and milk

pathways reduces the RAO (based on an excess cancer risk of $10^{-6}$) by about 50-fold, from $4 \times 10^{-2}$ mg/kg without beef and milk ingestion to $9 \times 10^{-4}$ mg/kg when beef and milk ingestion are included. Because in the human health BRA, potential risks associated with these exposure pathways were based on quadrant-wide average soil concentrations, an RAO driven by ingestion of beef and milk may not provide information useful to an evaluation of remedial alternatives for individual SWMUs.

- For some constituents, the excavation scenario yields the lowest RAO of the exposure scenarios modeled. Where this occurs for organic constituents in soil, the RAO is generally driven by the modeled exposures associated with inhalation of soil vapors. It is important to note that there are many uncertainties and conservative assumptions in the model used to estimate vapor concentrations. Therefore, the RAOs derived from this pathway should be interpreted with caution.

- The risk assessment for the recreational population demonstrates that average constituent concentrations across the quadrant do not present significant risks based on indirect exposures to constituents in soil from consumption of game that feed on the site. Furthermore, the RAOs protective of the recreational population are generally several orders of magnitude greater than the RAOs based on residential exposures.

- Because the conditions of exposure assumed under the residential scenario result in the lowest RAOs, the following observations related to residential exposure pathways are offered:

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- Dermal contact with soil drives the RAO for many of the organic and inorganic compounds. For organic compounds, the RAO derived for dermal contact was 1.5 to 10 times smaller than the RAO for soil ingestion, and for many inorganic compounds, the RAO was 4 to 15 times smaller. For PCBs, incidental ingestion of soil and dermal contact with soil are comparable. The relative significance of dermal contact as a contributor to exposure is influenced directly by the dermal absorption factor (i.e, the percentage of chemical in soil adhered to skin that is assumed to be absorbed dermally). The uncertainties about this factor and resultant estimates of exposure are discussed in Section 6.5.4.1.

- Ingestion of vegetables contributes significantly to the RAOs for several organic and inorganic constituents. However, because of uncertainties inherent in the vegetable uptake model, the same cautions in interpreting RAOs resulting from the excavation vapor model should also hold for these vegetable-derived RAOs.

- External gamma radiation drives the RAOs for uranium-235 and uranium-238. For technetium, the indirect pathways involving foodchain bioaccumulation, including ingestion of vegetables, beef, and milk drive the RAO.

Sediment and Surface Water

- RAOs for sediment and surface water have been developed for worker and recreational scenarios. For most chemicals, the surface water and sediment RAOs based on the recreational scenario are the lower of the two, although RAOs differ by only about two-fold.

- For organic chemicals (with the exception of PCBs), the pathway that drives the sediment RAO is dermal contact. See Section 6.5.4.1 for a discussion of the uncertainties associated with the dermal pathway. RAOs for PCBs based on the ingestion and dermal contact pathways are comparable. For inorganic compounds, either incidental ingestion or dermal contact may be the more significant pathway. Both incidental ingestion and dermal contact with surface water influence derivation of the surface water RAO.

## 6.8 Conclusions

### 6.8.1 Human Health BRA

#### 6.8.1.1 Introduction

A human health baseline risk assessment (BRA) was conducted to support risk-based decisions regarding the need for further action at SWMUs in Quadrant III. In performing this BRA, assessments of potential risk were conducted for each SWMU (see exceptions noted below) and, under selected scenarios, for the quadrant as a whole based on a set of reasonable maximum exposure (RME) assumptions. Discussions of the risk assessment findings for the SWMU-specific and quadrant-wide assessments are presented in

Sections 6.8.1.3 and 6.8.1.4 below. Because some portions of the inorganic constituents present in environmental media are naturally occurring, an assessment was performed of potential risks associated with naturally occurring constituents at tentative background levels in order to distinguish these potential risks from those that may be related to activities at the PORTS facility. The results of the background risk assessment are summarized in Section 6.8.1.2.

Risk assessments were performed for 16 of the 19 SWMUs in Quadrant III. Because of the spacial dispersion of the sampling locations for three SWMUs, the Recirculation Cooling Water System (RCW), the Sanitary Sewer System (SASW) and the Storm Sewer System (STSW), SWMU-specific assessments were considered inappropriate. Data from these SWMUs were included, however, in the assessment based on quadrant-wide average concentrations. In addition to the 16 SWMUs for which assessments were performed, potential risks associated with groundwater constituents were evaluated for two Quadrant III wells (F-31G and F-32B) that were located distant from other Quadrant III SWMUs.

### 6.8.1.2 Background Risks

Background levels of naturally occurring compounds in soils (based on an analysis of tentative background values) pose potentially significant health risks (i.e., noncancer HI greater than 1 or excess cancer risk greater than $10^{-6}$) for all future on-site exposure scenarios evaluated (i.e., future on-site worker, resident, excavation worker, and recreational population). Potential excess cancer risks associated with exposure to soil constituents at tentative background levels under these various future use scenarios are in the range of $10^{-4}$ to $10^{-6}$; these risks are largely attributable to arsenic and beryllium.

A background analysis has not been performed for groundwater, sediment, or surface water. As discussed below, however, background levels of inorganic or other non-plant related constituents in these media may contribute to the overall estimates of potential risk derived for each of the SWMUs. Risks associated with inorganic constituents and radiological parameters in soil and groundwater will be re-evaluated using the background analysis presented in the BSI, and results of this re-analysis will be addressed in the CAS/CMS.

### 6.8.1.3 SWMU-Specific RME Risks

#### 6.8.1.3.1 Groundwater and Soil Media

Potential risks under current and future land use conditions for each of the SWMUs considered in the Quadrant III BRA based on an assessment of soil and groundwater data are discussed in Section 6.5.3.4 and summarized below. Assessments of each SWMU for which groundwater and/or soil data were collected were performed for a current and future on-site worker, a future on-site resident, and an excavation worker. The categorization of SWMUs into one of three risks groups (see below) is based on the scenario involving a reasonable maximum exposure of a hypothetical future on-site resident.

The assessment of total potential risks for the for the future on-site worker and residential populations is based on data for groundwater from the Gallia aquifer only. A separate assessment of potential risks associated with constituents in the Berea aquifer was conducted; the findings of this assessment are summarized later in this section.

Noncancer HI values and excess cancer risk levels for a future on-site resident, by SWMU and by medium, are presented schematically in Figures 6.5 and 6.6. Additional

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figures for the future worker, current worker, and excavation worker scenarios are presented in Figures 6.7 to 6.12. To differentiate between potential risks attributable to constituents in groundwater (Gallia aquifer) and soil, figures have been prepared presenting potential risks associated with both media, with constituents in groundwater only, and with constituents in soil only.

The assessment of potential residential risks for each SWMU as presented in Section 6.5.4.3 of the BRA considers potential exposures to constituents in a given SWMU as well as exposures calculated using quadrant-wide average concentrations (i.e., exposures associated with beef and milk ingestion and with recreational activities). To support the CMS, the following discussions of residential risk for each SWMU, however, are based only on potential risks associated with constituents present in the specific SWMU.

Based on the analysis of SWMU-specific risks associated with groundwater (Gallia aquifer) and soil, SWMUs were categorized into one of three general groups based on potential carcinogenic and noncarcinogenic risk as follows:

Target Risk Levels Not Exceeded. SWMUs in this group pose negligible potential carcinogenic risk (less than $10^{-6}$) and negligible potential noncarcinogenic risk (HI less than one) in all exposure scenarios modeled. One SWMU falls into this group:

- West Drainage Ditch

In considering the nature of potential risks posed by this unit, it should be noted that estimated risks for WDD are based only on constituents present in soil; groundwater samples were not taken at this unit. Thus, to the extent that constituents in groundwater,

either site-related or non-site-related, contribute to total risk, the total estimated risk at this unit may be underestimated.

Within Target Risk Levels. SWMUs in this group pose potential carcinogenic risks within the U.S. EPA range of concern (between $10^{-6}$ and $10^{-4}$). Three SWMUs fall into this group:

- X-326 Process Building (X-326)
- X-744S, X-744T, X-744U Lithium Storage Warehouses (X-744S)
- X-2230N West Holding Pond No. 2 (X-2230N)

In considering the nature of potential risks posed by these three units, it should be noted that estimated risks for the X-744S and X-2230N units are based only on constituents present in soil; groundwater samples were not taken at these two units. Thus, to the extent that constituents in groundwater, either site-related or non-site-related, contribute to total risk, the total estimated risk at these two units may be underestimated.

Target Risk Levels Exceeded. SWMUs in this group pose significant potential carcinogenic risk (greater than $10^{-4}$) or significant potential noncarcinogenic risk (HI greater than one) in one or more exposure scenarios modeled. Thirteen SWMUs fall into this group:

- X-230J3 West Environmental Sampling Building and Intermittent Containment Basin (X-230J3)
- X-230J5 West Holding Pond and Oil Separation Building (X-230J5)
- X-330 Process Building (X-330)

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- X-530A Switchyard including X-530B Switch House; X-530C Test and Repair Building; X-530D Oil House; X-530E Valve House; X-530F Valve House; X-530G GCEP Oil Pumping Station (X-530A)
- X-615 Abandoned Sanitary Sewage Treatment Facility (X-615)
- X-616 Liquid Effluent Control Facility/Former Chromium Sludge Lagoons (X-616)
- X-740 Waste Oil Handling Facility (X-740)
- X-744N, X-744P, X-744Q Warehouse and Associated Oil Construction Headquarters Area (X-744N)
- X-745C West Cylinder Storage Yard (X-745C)
- X-6619 and X-6614E Sewage Treatment Facility (X-6619)
- X-7725 Recycle Assembly Building, X-7745R Recycle Assembly Storage Yard and Initial Construction Bulk Fuel Storage Area (BFS)
- Don Marquis Substation, Associated Containment Ponds and Drainage Ditches (DMRQ)
- Groundwater Well F-31G

Where groundwater wells in the Gallia aquifer are located in the vicinity of a SWMU and future domestic use of groundwater from these wells was assumed, potential risks associated with constituents in groundwater for these units generally drive the total risks. It should be noted that risks are in large part attributable to constituents that may occur naturally. Risks associated with inorganic constituents and radiological parameters in groundwater will be re-evaluated using the background analysis presented in the BSI, and results of this re-analysis will be addressed in the CAS/CMS.

Arsenic in soil or Gallia groundwater is one of the most significant contributors to overall risk in 9 of the 13 SWMUs that exceed target risk levels. In addition to arsenic,

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other inorganic compounds (including beryllium, chromium, and vanadium) in groundwater from the Gallia aquifer and soil contribute significantly to the potential cancer and noncancer risks associated with a number of the SWMUs. Because of the significance of risks posed by inorganic constituents in PORTS media and because even tentative background levels of arsenic and beryllium in soil at PORTS pose a significant risk, further consideration of health risks associated with naturally occurring constituents at background levels is recommended before remedial actions are proposed. Remedial decisions should also take into consideration the degree of uncertainty in the arsenic cancer SF articulated by U.S. EPA in IRIS (U.S. EPA, 1994a). The Administrator of the U.S. EPA has counseled that "In reaching risk management decisions in a specific situation, risk managers must recognize and consider the qualities of risk estimates. The uncertainties associated with ingested inorganic arsenic are such that estimates could be modified downwards by as much as an order of magnitude, relative to risk estimates associated with most other carcinogens" (U.S. EPA, 1994a).

Technetium does not pose a significant risk in the groundwater or soil of any SWMU in Quadrant III. Uranium isotopes in soil pose potential risks of 1 to 2 x $10^{-6}$ in three Quadrant III SWMUs. These risks result from external radiation exposure from the isotopes in the soil of SWMUs X-230J3, X-230J5, and X-615. The estimated risks from external radiation exposure are associated with maximum detected uranium concentrations in soil that exceed background uranium levels by only 2- to 3-fold.

Organic constituents in soil and groundwater pose a potentially significant risk (noncancer HI greater than 1 or excess cancer risk greater than $10^{-6}$) in some of the SWMUs under the conditions modeled in this BRA. PCBs in soil present a potentially significant risk in SWMUs X-230J5, X-530A, X-615, X-744S, and X-745C. PAHs in soil present a potentially significant risk in SWMUs X-230J3, X-230J5, X-530A, X-615, X-

740, X-744N, X-744S, and X-745C. In SWMUs X-326, X-530A, X-616, X-740, X-744S, and DMRQ, chlorinated hydrocarbon compounds in groundwater (Gallia aquifer) or soil also pose excess cancer risks greater than $10^{-6}$. Other organic constituents that pose potentially significant risks include the following: benzene in the soil of SWMUs X-230J3 and X-615; nitrobenzene in the soil of SWMU X-230J3; and heptachlor, gamma-chlordane, and vinyl acetate in the soil of SWMU BFS.

As noted above, a separate assessment was performed for groundwater from the Berea aquifer. This assessment shows that potentially significant risks (noncancer HI greater than 1 or excess cancer risk greater than $10^{-6}$) are due primarily to arsenic. Exposure to antimony, beryllium, and chlorinated hydrocarbons also pose potentially significant risks. Because an analysis taking into account approved background levels of naturally occurring or other non-plant-related constituents in groundwater from the Gallia or Berea aquifer was not performed as part of this BRA, it is not possible to differentiate between potentially site-related risks and risks attributable to background. As stated previously with respect to groundwater from the Gallia aquifer, remedial decisions should take into consideration the extent to which background levels of naturally occurring inorganic constituents contribute to total risk and the degree of uncertainty in the cancer assessment for arsenic.

Under the current use scenario for an on-site worker, target risk levels (i.e., noncancer HI greater than 1 or excess cancer risk level greater than $10^{-4}$) are exceeded only at SWMU X-230J3. At the X-230J3 unit, excess cancer risks are principally associated with PAHs in 0 to 2 ft soils. Potential excess cancer risk levels between $10^{-6}$ and $10^{-4}$ for the current on-site worker are posed by exposure to media at SWMUs X-530A, X-615, X-740, X-744N, X-744S, X-745C, X-6619 and BFS. It should be noted that shallow soil data

(i.e., 0 to 2 ft) upon which the current use scenario was based were not available for SWMU X-616.

6.8.1.3.2 Sediment and Surface Water Media

Potential risks under current and future land use conditions for each of the SWMUs considered in the Quadrant III BRA based on an assessment of RFI data for sediment and/or surface water are discussed in Section 6.5.3.4 and summarized below. Assessments of each SWMU for which sediment and surface water data were collected were performed for an on-site worker and a future on-site recreational population. Noncancer HI values and excess cancer risk levels for worker and recreational scenarios are presented in Figures 6.13 to 6.16. The summary below is limited to the scenario involving a reasonable maximum exposure of a hypothetical future on-site recreational population. In general, the RME recreational population exposure represents a conservative characterization of potential risk associated with the constituents present in these media.

Based on the analysis of SWMU-specific risks associated with sediment and surface water, SWMUs were categorized into one of three general groups based on potential carcinogenic and noncarcinogenic risk as follows:

Target Risk Levels Not Exceeded. SWMUs in this group pose negligible potential carcinogenic risk (less than $10^{-6}$) and negligible potential noncarcinogenic risk (HI less than 1) in all exposure scenarios modeled. No SWMUs fall into this group.

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Within Target Risk Levels. SWMUs in this group pose potential carcinogenic risks within the U.S. EPA range of concern (between $10^{-6}$ and $10^{-4}$). One SWMU falls into this group:

- X-2230N West Holding Pond No. 2 (X-2230N)

Target Risk Levels Exceeded. SWMUs in this group pose significant potential carcinogenic risk (greater than $10^{-4}$) or significant potential noncarcinogenic risk (HI greater than 1) in one or more exposure scenarios modeled. Three SWMUs fall into this group:

- X-230J5 West Holding Pond and Oil Separation Building (X-230J5)
- Don Marquis Substation, Associated Containment Ponds and Drainage Ditches (DMRQ)
- West Drainage Ditch (WDD)

It should be noted that naturally occurring inorganic constituents contribute significantly to total potential risks associated with these four SWMUs with estimated potential cancer risks in excess of $10^{-6}$. Because background levels of naturally occurring or other non-plant-related constituents in sediment and surface water have not yet been established, it is not possible to differentiate between potentially site-related risks and risks attributable to background.

Arsenic and beryllium in sediment are significant contributors to overall risk in all four of these SWMUs and in surface water at DMRQ. Manganese is also a significant contributor to noncancer risks at levels presents in surface water at DMRQ and in sediment at WDD. As stated previously with respect to soil and groundwater, remedial decisions should take into consideration the extent to which background levels of naturally occurring

inorganic constituents contribute to total risk and the degree of uncertainty in the cancer assessment for arsenic.

Organic constituents in sediment that pose a potentially significant excess cancer risk (greater than $10^{-6}$) are PAHs at SWMUs X-230J5 and WDD, and PCBs in X-230J5, X-2230N, and WDD. In surface water, 1,2-dibromo-3-chloropropane at WDD and benzo(a)anthracene at DMRQ present excess cancer risks in excess of $10^{-6}$. Technetium or uranium isotopes do not pose a significant risk in the sediment or surface water of any SWMU in Quadrant III.

6.8.1.3.3 Incremental Risks

Because naturally occurring inorganic compounds in PORTS media present a risk of their own, an incremental risk assessment was performed to distinguish that portion of total risk likely attributable to naturally occurring background levels from that portion of the risk likely attributable to facility operations. Incremental risks were calculated by subtracting risks associated with tentative background levels of naturally occurring inorganic constituents in soil from risks associated with total constituent levels. The resulting risks (i.e., incremental risks) are those associated with concentrations of constituents in excess of background.

In the assessment of incremental risks, Quadrant III SWMUs fall into the same general risk categories as in the assessment of risks based on total constituent concentrations. It is noted, however, that the current incremental risk assessment is based only on tentative background data for soil. Consideration of the background analysis for groundwater constituents presented in the BSI may allow differentiation of background-related risks and potential facility-related risks for this medium.

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6.8.1.3.4 Risks Developed using Typical Exposure Assumptions

Appendix H.4 presents risk estimates for the typical exposure assessment, which was prepared as one means of characterizing the variability or uncertainty in the exposure estimates for the scenarios considered in the Quadrant III BRA. Although overall risks are less for the typical case than the RME case, the SWMUs fall into the same general risk categories with the following exceptions:

- SWMU X-2230N and groundwater well F-31G transfer from the risk category "Within Target Risk Levels" to "Target Risk Levels Not Exceeded."

- SWMUs X-230J5 (groundwater/soil and sediment/surface water), X-615 and X-616 transfer from the risk category "Target Risk Levels Exceeded" to "Within Target Risk Levels."

6.8.1.4 Quadrant-Wide Risks

The assessment of potential risks under current and future land use conditions based on quadrant-wide average concentrations is presented in Section 6.5.3.3. For the indirect exposure pathways of ingestion of beef and milk from cows grazed on Quadrant III soils, PCBs, PAHs, gamma-chlordane and technetium contribute to potential excess cancer risks above $10^{-6}$. For the sediment and surface water media, similar to the assessments for individual SWMUs, risks in excess of $10^{-6}$ are generally associated with arsenic, beryllium, PCBs, PAHs, and 1,2-dibromo-3-chloropropane.

### 6.8.2 Preliminary Ecological Risk Assessment (PERA)

The purpose of this PERA was to assemble the existing information on: (1) the general ecology of Quadrant III; (2) the likely exposure pathways and receptors in the area; and (3) the fate, exposure levels, and ecotoxicity of the chemicals detected in surface water, sediment, and soil. The PERA analysis is intended to screen the COCs with regard to their potential ecological risks and their likely SWMU sources. The results of the PERA provide a basis to focus subsequent analysis, such as a facility-wide and watershed-based BERA.

#### 6.8.2.1 General Conclusions

Quadrant III of PORTS contains 19 SWMUs, 15 of which were considered in this PERA. Soil (0-2 ft depth only), sediment, and surface water samples were analyzed for a variety of inorganic and organic chemicals and radionuclides. These chemical analyses form the basis of the exposure estimates for ecological receptors, including sensitive aquatic species, and terrestrial plants and soil invertebrates. Calculated RME concentrations were compared to screening benchmarks (i.e., adverse effect levels either promulgated/proposed by various regulatory agencies or derived from available toxicity data) to determine if there is a potential risk to ecological receptors. Based on this screening analysis, conducted for individual SWMUs, as well as for the quadrant as a whole, the following conclusions and further considerations are presented:

- As a screening method, the PERA is based on the use of conservative ecotoxicological benchmarks that are compared to "upper bound" (i.e., 95% UCL or maximum) environmental levels of the various COCs. Therefore, if a COC does not exceed a benchmark, it is probable that the ecological risk from this COC is

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negligible. Conversely, an exceedence does not necessarily mean that a risk exists, but does suggest that further evaluation may be warranted.

- Both quadrant-wide and SWMU-by-SWMU risks were evaluated in this PERA. Quadrant-wide RME concentrations (represented by the 95% UCL on the mean or the maximum detected level, whichever is less) for each COC were compared to benchmark values (Table 6.317). SWMU-specific RME concentrations (represented as the maximum detected level) for each COC were compared to the same benchmark values (Appendices H.11 and H.12).

- Three watersheds were identified within Quadrant III. One SWMU drains to watershed "A," 14 drain at least partially to watershed "B," and one drains partially to watershed "C." One SWMU (X-744N) drains to more than one watershed. Exceedences of at least one available benchmark in each environmental medium sampled were observed for all three watersheds.

- Twenty-six inorganic COCs, 60 organic COCs, and 2 radionuclides were detected in at least one environmental medium (sediment, surface water, and 0-2 ft soil).

  - Twenty-one of the 26 inorganic COCs were detected in all three media. Twenty-three of 26 inorganic COCs were found in sediment, 22 of 26 were found in surface water, and 25 of 26 were detected in soil.

  - Seven organic COCs were detected in all three media (anthracene, benzo[a]anthracene, chloroform, fluoranthene, phenanthrene, pyrene, and xylene). Twenty-seven of the 60 organic COCs were detected in sediment, 19 of 60 were detected in surface water, and 49 of 60 were detected in soil.

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- Uranium and technetium were detected in sediment and soil, but not in surface water.

- Tentative background levels were available for 21 of 25 inorganic COCs detected in soil (all except antimony, cyanide, lithium, and selenium). The quadrant-wide RME levels were less than background for 17 of these 21 inorganic COCs (Table 6.277). The four remaining inorganic COCs (calcium, magnesium, silver, and sodium) (Table 6.275) often exceeded background. Uranium was present in some soil samples at concentrations above background. No background level exists for technetium since it is not a naturally occurring compound. There were no background levels for inorganic COCs or radionuclides COCs in sediment or surface water. There were no tentative background levels available for organic COCs.

- There were a number of COCs for which screening benchmarks were not available for a given medium (see Table 6.313). Benchmarks were available for 13 of 23 detected inorganic COCs and 24 of 27 organic COCs in sediment. Benchmarks were available for 21 of 22 detected inorganic COCs and 18 of 19 detected organic COCs in surface water. Phytotoxicity benchmarks were available for 17 of 22 inorganic COC for which the maximum concentrations were above tentative background (SWMU by SWMU analysis); three of eight inorganic COCs for which the RME concentrations were above background (quadrant-wide analysis); and 17 of 49 organic COCs in soil. Benchmarks for soil invertebrate toxicity were available for eight of 22 inorganic COCs for which the maximum concentrations were above preliminary background (SWMU by SWMU analysis); zero of eight inorganic COCs for which the RME concentrations were above background (quadrant-wide analysis); and six of 49 organic COCs in soil. No screening

benchmarks were available for radionuclides in any environmental medium. There were no SWMUs for which benchmarks were available for all detected COCs.

- Table 6.312 lists 38 organic COCs (out of 60 detected) that have a log $K_{ow}$ of 3 or higher and that may have the potential to bioaccumulate through the foodchain. A $K_{ow}$ value for O,O,O-triethylphosphorothioate was not available. Screening benchmarks were not available for bioaccumulation of metals or for bio-uptake of any COCs into higher plants. However, some heavy metals are known to be taken up by plants and organic forms of certain metals bioaccumulate in the foodchain (e.g., organo-mercury and organo-lead complexes).

6.8.2.2 Conclusions Related to the Quadrant-Wide Analysis

The quadrant-wide analysis separates those COCs that pose negligible risk to ecological receptors from those that may pose a risk based on a comparison of the RME concentration across the quadrant with suitable screening benchmark values. The potential for risk is further defined by medium (surface water, sediment, and soil). At the PERA level of analysis, the quadrant-wide magnitude of exceedence was not considered.

Results of the quadrant-wide screen indicate that a potential ecological risk exists for 15 organic COCs (Table 6.317); they include 11 organic COCs in sediment, 3 organic COCs in surface water, and 8 organic COCs in soil (6 as a result of exceeding phytotoxicity benchmarks and 2 as a result of exceeding soil invertebrate toxicity benchmarks). Nine of the 60 organic COCs may be dropped from further consideration because their RME levels were below all available benchmarks in the media in which they were detected. They are: carbon disulfide, dibromochloromethane, 1,2-dibromo-3-chloropropane, 1,4-dioxane, isobutyl alcohol, isophorone, kepone, pentachlorophenol, and

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gamma-BHC. The remaining 36 organic COCs did not have exceedences, but also did not have a complete set of benchmarks and therefore could not be fully screened.

A potential ecological risk exists for 20 inorganic COCs (Table 6.317). Seven inorganic COCs exceeded a benchmark in sediment, 17 exceeded a benchmark in surface water, and lithium exceeded a benchmark for phytotoxicity (none exceeded soil invertebrate benchmarks). None of the inorganic COCs that were above background levels were dropped from further consideration based on the PERA analysis.

An analysis of potential ecological risks associated with radionuclides was performed by comparing Quadrant III uranium and technetium concentrations in soil, surface water, and sediment to the concentrations calculated in the Phase I Quadrant I/II RFIs, for which a quantitative assessment of radionuclide risks was undertaken. This analysis suggests that Quadrant III radionuclide concentrations should not pose a significant risk to ecological receptors.

### 6.8.2.3 Conclusions Related to the SWMU by SWMU Analysis

The PERA analysis of data for individual SWMUs provides a means of focusing further analysis on certain SWMUs for which potential risks may be higher and identifying sources of COCs. The table below provides a ranking of the SWMUs by their total number of exceedences and may be useful for prioritizing analysis in a more rigorous assessment, such as a BERA. An exceedence occurred in every SWMU where benchmarks were available for comparison.

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| Ranking of Quadrant III SWMUs by Number of Exceedences | |
|---|---|
| **SWMU** | **Number of COCs Exceeded[1]** |
| DMRQ | 33 |
| WDD | 33 |
| X-230J5 | 18 |
| X-2230N | 13 |
| X-530A | 12 |
| X-745C | 11 |
| X-740 | 7 |
| X-230J3 | 6 |
| BFS | 6 |
| X-615 | 6 |
| X-744N | 5 |
| X-744S | 4 |
| X-6619 | 1 |

[1] An exceedence in an environmental medium was only counted once for a given COC (i.e., if a COC exceeded both a plant and soil invertebrate benchmark, it was only counted as one exceedence in soil.

### 6.8.2.4 Conclusions Related to the Watershed Analysis

In the watershed analysis, individual samples in SWMUs that drain to more than one watershed are analyzed so that exceedences within the SWMU can be assigned to the appropriate watershed.

One of the SWMUs (X-744N) evaluated in the PERA appears to drain to two watersheds (Table 6.273). The analysis presented in Section 6.6.7.4 shows that exceedences for zinc, 4,4'-DDT, and benzo(a)pyrene in soil (plant benchmarks) were

assigned to watershed "B"; exceedences for lithium (plant benchmark), benzo(a)pyrene (plant benchmark), and 1,2,4-trichlorobenzene (invertebrate benchmark) in soil were assigned to watershed "C."

6.8.2.5 Additional Observations

There are additional aspects of the PERA analysis that can be used to help focus and prioritize a more detailed assessment, such as a BERA. These aspects include: unique COCs; maximum COC levels; and the number and magnitude of benchmark exceedences by COC.

- Forty-eight of the 177 total COCs were detected at only one SWMU (Table 6.278). An additional three COCs (antimony, bromodichloromethane, and chloroform) were detected at more than one SWMU but only one environmental medium. These two groups of COCs were considered unique COCs. Sixty-five percent (31 of 48) of the unique COCs were found at either DMRQ (16 unique COCs) or WDD (15 unique COCs). A total of 10 SWMUs had unique COCs. It should also be noted that benchmarks could not be identified or developed for some of these unique COCs and, therefore, they could not be assessed for potential risk.

- Two SWMUs, WDD (58 maximum values) and DMRQ (37 maximum values) accounted for 56 percent (95 of 177) of the maximum detected levels for all COCs in all media combined (Tables 6.301 and 6.302).

- Among inorganic COCs, zinc had the greatest number of exceedences with 16 (combining all three media), followed by chromium with 12 exceedences,

and iron with 11 exceedences. Among organic COCs, both benzo(a)anthracene and benzo(a)pyrene had nine exceedences. Dibenz(a,h)anthracene was third highest among organic COCs with five exceedences.

- Although magnitude of exceedence is not a deciding factor in the PERA analysis, it can provide information useful to a more detailed assessment, such as a BERA. Among inorganic COCs, the highest magnitudes of exceedence were for cyanide in sediment, magnesium in surface water, and iron in soil. Among organic COCs, the highest magnitudes of exceedence were for anthracene in sediment and surface water, and 1,2,4-trichlorobenzene in soil. The magnitudes of exceedence for all COCs are listed in Table 6.318 to 6.321.

Based on the PERA analysis, the following should be considered when determining the necessity for, and the scope of, more detailed analysis:

- A review of available data suggests that the terrestrial and aquatic habitats in Quadrant III may support numerous types of wildlife indigenous to southcentral Ohio. A more intensive survey of the habitat in Quadrant III would be needed to determine whether it can support the threatened and endangered species listed in Table 6.274 and Appendix H.9.

- One-hundred and sixteen of 244 potential comparisons between exposure estimates and screening benchmarks could not be made because benchmarks and/or toxicity data were unavailable. Information is needed to develop screening benchmarks for these chemicals and media as part of more

detailed analysis (possibly using "surrogate compounds" for which toxicity data are available).

- There were many instances in which the maximum measured level of a particular inorganic COC was below its tentative soil background level but above the derived benchmark. The derivation and validity of these soil benchmarks, as well as that of the background analyses, need further examination.

- There were a number of instances where plant benchmarks are based on nutrient solution values because soil concentrations were not available. Soil benchmarks based on nutrient solution are more conservative than those based on soil concentrations, and the uncertainty about these benchnmarks is considered greater than about those based on soil concentrations.

- Fraction organic carbon data (Foc) in sediment were not available for use in the PERA. Therefore, a value of 4% organic carbon was assumed based on Mackay et al. (1992). Because Foc is used to estimate sediment benchmarks, an assumed value of 4% organic carbon may either under or overestimate benchmark values for PORTS, depending on whether the actual Foc in PORTS sediments is lower or higher than that assumed here.

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# 7.0 CONCLUSIONS AND PROPOSED ADDITIONAL INVESTIGATION

The objectives of the RFI at PORTS, as listed in the OEPA Consent Decree and the U.S. EPA Consent Order, are enumerated in Section 1.0 (Introduction) of this report. Presented below is a discussion of how each of these objectives (shown in boldface below) were achieved during the RFI, including proposed additional investigation.

- ***Characterize the environmental setting, including groundwater, surface water and sediment, soil, and air***

As discussed in Section 2.0 (Characterization of Environmental Setting) of this report, the environmental settings of Quadrant III and the PORTS facility are well understood as a result of this and previous investigations. In addition, background levels of naturally occurring constituents have been determined and are specified in the Background Sampling Investigation of Soil and Groundwater Final Report (BSI) (U.S. DOE, 1996a). Details of the Air RFI investigation are included in the Final Air Pathway RCRA Facility Investigation Report (U.S. DOE, 1996b).

- ***Define and characterize sources of contamination***

Potential sources of contamination were identified during development of the Quadrant III DOCC (Geraghty & Miller, Inc., 1992a). Waste Characterization Data Sheets, which include detailed information regarding the physical and chemical properties of potential contaminants associated with these sources, were developed during the RFI and are included in this report. The nature of the operations, the structure, and the history of waste disposal at each unit were also reviewed to develop SWMU-specific scopes of work. During this review, point sources of potential contamination were identified at three of the 19 SWMUs investigated. To complete

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source characterization of these three SWMUs, sediment and surface-water samples were collected for comprehensive analyses. These three SWMUs are as follows:

- X-230J5 West Environmental Sampling Building/Containment Basin
- X-2230N West Holding Pond No. 2
- Don Marquis Substation

Based upon the results of this sampling, the character of sediment, waste water, surface water, or soil associated with these SWMUs has been well defined. No additional investigation is required to characterize sources of contamination at these SWMUs.

- ***Characterize the vertical and horizontal extent and degree of contamination of the environment***

As discussed in Section 4.0 (Technical Approach and Unit Investigations in Quadrant III), contamination of environmental media was identified during this investigation at 17 of the 19 SWMUs in Quadrant III. At 15 of these 17 SWMUs, the nature (constituents and maximum concentrations) and the vertical and horizontal extent of contamination has been determined. Based upon the RFI data, further investigation is required at the X-740 Waste Oil Handling Facility. Closure work was conducted at the X-740 Waste Oil Handling Facility in October 1994 concurrent with the RFI and is referred to as the Phase II Investigation. Subsequent non-RFI field work at X-740 was conducted in the Spring of 1996; the results of this investigation are included in the Risk-Based RCRA Closure Plan for X-740. This document is currently being reviewed by OEPA. Additional non-RFI sampling was also conducted at the West Drainage Ditch during the Summer of 1996. A radiological survey of the soil and sediment in the West Drainage Ditch detected elevated technetium levels at 14 locations in West Drainage Ditch. Soil/sediment at these areas were excavated and

subsequent confirmatory sampling indicated that the elevated radioactivity had been removed. This removal action and the sampling data will be addressed in the CAS/CMS.

- ***Assess the risk to human health and the environment resulting from possible exposure to contaminants***

An evaluation of potential risks to human health associated with each SWMU in Quadrant III was conducted as part of the RFI to support risk-based decisions regarding the need for further action. Risks were evaluated under two hypothetical future-use scenarios and the current-use scenario. Complete evaluations of soil and groundwater samples collected from areas adjacent to three SWMUs (Recirculating Cooling Water System (RCW), Sanitary Sewer System (SASW), and Storm Sewer System (STSW) were not performed because of the spatial variation of data associated with these units. However, data from these sampling locations were considered in the overall evaluation of the quadrant and in the evaluations of other SWMUs located near these SWMUs. It should be noted that the analysis of data collected during the RFI revealed no evidence of contamination that could be attributed directly to the RCW, the SASW, or the STSW lines.

Risk evaluation was performed using tentative background values for metals and naturally occurring radiological parameters. These values were calculated as part of the Quadrant I and Quadrant II Phase I RFIs conducted in 1991. (Background concentrations of naturally occurring constituents must be established before risks can be fully evaluated). Although background levels have since been revised and characterized in the BSI, background values for soil and groundwater were not approved until after the assessment of risk for Quadrant III SWMUs had been completed. Therefore, approved background values presented in the BSI are not incorporated into this report. In addition, inorganic constituents and naturally occurring radiological

parameters were not evaluated in this report and will be assessed in the CAS/CMS. Risks associated with SWMUs in Quadrant III will be assessed after background values are evaluated in the CAS/CMS. If this reevaluation of risk indicates that risk levels associated with a unit are "acceptable," no further action will be proposed at that SWMU; if risk levels are "unacceptable," further action will be proposed. The results of the risk evaluation conducted during this investigation are summarized below.

Based on an analysis of risks associated with a hypothetical future-residential-use scenario and using a set of RME assumptions, SWMUs for which soil or groundwater data were collected can be separated into three groups classified according to potential carcinogenic and non-carcinogenic risk. Similarly, SWMUs for which surface water or sediment data were collected can be separated into risk categories based on future-recreational-use scenario. Unless otherwise indicated, the following risk categorization is based on soil or groundwater data.

## Target Risk Levels Not Exceeded

SWMUs in this group pose negligible carcinogenic risk (less than $10^{-6}$) and negligible non-carcinogenic risk (hazard index [HI] less than 1) for the future-residential-use scenario. One SWMU is included in this group:

- West Drainage Ditch

Within Target Risk Levels

SWMUs in this group pose carcinogenic risks within the U.S. EPA range of concern (between $10^{-6}$ and $10^{-4}$) for the future-residential-use scenario. Three SWMUs are included in this group:

- X-326 Process Building (X-326)
- X-744S, X-744T, X-744U Lithium Storage Warehouses (X-744S)
- X-2230N West Holding Pond No. 2 (X-2230N)

Target Risk Levels Exceeded

SWMUs in this group pose a significant carcinogenic risk (greater than $10^{-4}$) or significant non-carcinogenic risk (HI greater than 1) for the future-residential-use scenario. Twelve SWMUs are included in this group:

- X-230J3 West Environmental Sampling Building and Intermittent Containment Basin (X-230J3)
- X-230J5 West Holding Pond and Oil Separation Building (X-230J5)
- X-330 Process Building (X-330)
- X-530A Switchyard including X-530B Switch House; X-530C Test and Repair Building; X-530D Oil House; X-530E Valve House; X-530F Valve House; X-530G GCEP Oil Pumping Station (X-530A)
- X-615 Abandoned Sanitary Sewage Treatment Facility (X-615)
- X-616 Liquid Effluent Control Facility/Former Chromium Sludge Lagoons (X-616)
- X-740 Waste Oil Handling Facility (X-740)

- X-744N, X-744P, X-744Q Warehouse and Associated Oil Construction Headquarters Area (X-744N)
- X-745C West Cylinder Storage Yard (X-745C)
- X-6619 and X-6614E Sewage Treatment Facility (X-6619)
- X-7725 Recycle Assembly Building, X-7745R Recycle Assembly Storage Yard and Initial Construction Bulk Fuel Storage Area (BFS)
- Don Marquis Substation, Associated Containment Ponds and Drainage Ditches (DMRQ)

Based on an evaluation of sediment and surface-water data under the future-recreational-use scenario, only one additional SWMU, the West Drainage Ditch, exceeded target risk levels.

The criteria used to determine if sufficient data have been collected during the RFI to support the risk assessment are shown on Figure 4.2 and discussed in Section 4.2 (Technical Approach). Based upon a review using these criteria, sufficient data for the risk assessment have been collected to support the risk assessment at all SWMUs investigated.

- ***Support the CAS/CMS***

The results of the RFI provide a foundation for the Quadrant III CAS/CMS, which will be completed upon completion of the RFI. Data were collected during the Quadrant III Phase I and Phase II RFI to characterize the nature and extent of contamination in environmental media and to describe the environmental setting of the facility (including site geology/hydrogeology and groundwater flow directions). Geotechnical data including bulk density, particle density, grain size analysis, soil permeability, Atterberg limits, standard Proctor analysis, soil porosity, cation exchange capacity, and total organic carbon were collected during the Quadrant I/Quadrant II

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Phase I/Phase II RFIs (Geraghty & Miller, Inc., 1992b, 1992c, 1994a, and 1994b, respectively). This combination of geologic/hydrogeologic and geotechnical data will be critical in the evaluation of corrective measure technologies that will be performed as part of the CAS/CMS. A preliminary evaluation of applicable or relevant and appropriate requirements (ARARs) for the PORTS facility was conducted in 1992 (Houlberg, et al, 1992). A complete review of ARARs will be conducted during the CAS/CMS.

Additional investigation was conducted to sufficiently define the area and/or volume of contaminated environmental media for the CAS/CMS. The locations and number of samples for this investigation were based on a data evaluation of the entire RFI analytical data set. The data collected to support the CAS/CMS are included in Appendix D2.

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## 7.1 REFERENCES

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QIII INVESTIGATIVE SAMPLE LOCATIONS WITH TOPOGRAPHIC CONTOURS
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